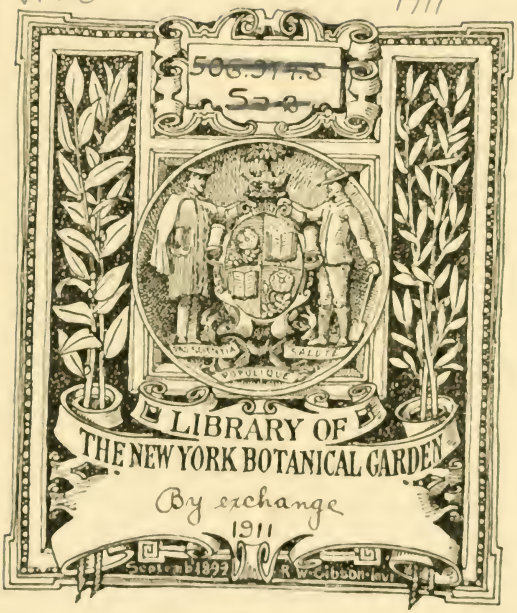

TRANSACTIONS

OF

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CONTENTS.

CORRECTIONS.

P. 20, line 14—For *232|07|1* read *233|07|1.*

P. 39, line 3 from bottom—For *wiil* read *will.*

P. 43, line 7—For $\frac{r\,(r+1)\,(r+2)\,r+3}{1.\,2.\,3.\,4}$ read

$$\frac{r\,(r+1)\,(r+2)\,(r+3)}{1.\,2.\,3.\,4}$$

P. 49, line 2—For $\frac{n\,(n+1)\,(n+2)\,(n+3)}{1.\,2.\,3}$ read

$$\frac{n\,(n+1)\,(n+2)\,(n+3)}{1.\,2.\,3.\,4}$$

P. 225, line 10—For *napsida* read *Synapsida.*

P. 290, line 5 from bottom—For *first* read *second.*

P. 310, line 4—For *seem* read *seems.*

P. 318, line 3—For *by physiological conditions of the individuals* read *by the physiological condition of the individual.*

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Wassermann, Prof. Dr. A.....University of Berlin, Germany.
Wittmack, Geh. Reg. Rath Prof. Dr. L.....University of Berlin, Germany.

† Deceased.

3. Active Members.

Alleman, Gellert[1].....Swarthmore College, Swarthmore, Pa.
Allen, George L.....26 Westmoreland Pl.
Allison, James E.....Merchants' Laclede Bldg.
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Ameiss, F. C.....3906 Olive St.
Ammerman, Charles.....McKinley High School.
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Armbruster, Wm. J.....3622 Shenandoah St.

Bagby, Julian[1].....New Haven, Mo.
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Baker, Robert H.[1].....University of Missouri, Columbia, Mo.
Baldwin, Roger N.....3739 Windsor Pl.
Barck, Carl.....Humboldt Bldg.
Barnard, George D.....Vandeventer and Laclede Aves.
Barroll, Joseph R.....4603 Berlin Ave.
Baskett, James Newton.....5910 Etzel Ave.
Baumgarten, Walter.....Humboldt Bldg.
Bay, J. Christian[1].....Crerar Library, Chicago, Ill.
Beckwith, Thomas[1].....Charleston, Mo.
Beede, J. W.[1].....822 Hunter Ave., Bloomington, Ind.
Bemis, S. A.....Fourth and Poplar Sts.
Bender, Cloyd Raymond[1].....307 Glen Ave., Council Bluffs, Iowa.
Berninghaus, J. A.....Central National Bank.
Bessey, Charles Edwin[1].....University of Nebraska, Lincoln, Neb.
Bessey, Ernst A.[1].....Michigan Agricultural College, East Lansing, Mich.
Blair, V. P.....Metropolitan Bldg.
Blankinship, Joseph William.[1].2329 Carlton St., Berkeley, Cal.

[1] Non-resident.

Blewett, Ben.....Ninth and Locust Sts.
Bock, George W.....2904 Allen Ave.
Borgmeyer, Charles J.....St. Louis University.
Bostwick, Arthur E.....4654 Berlin Ave.
Bradshaw, Preston J.....Liggett Bldg.
Brandenburger, Louis A.....3614 Cleveland Ave.
Brandenburger, W. A.....1406 Syndicate Trust Bldg.
Branner, J. C.[1].....Stanford University, Cal.
Brannon, Melvin A.[1].....University of North Dakota, Grand Forks, N. Dak.
Brennan, Martin S.....6304 Minnesota Ave.
Brimmer, George G.....6900 Michigan Ave.
Britton, F. H.[1].....Kirkwood, Mo.
Brock, James E.....Mississippi Valley Trust Co.
Brockman, F. W.....3710 N. Grand Ave.
Brookings, Robert S.....5125 Lindell Boul.
Brookmire, James H.....315 North Fourth St.
Brown, Arthur A.....4023 West Pine Boul.
Brown, Daniel S.....2212 DeKalb St.
Brown, Willi.....5351 Waterman Ave.
Browne, Clarence I.....4630a Delmar Ave.
Buckley, Ernest Robertson[1]...1364 Peoples Gas Bldg., Chicago, Ill.
Buehler, H. A.[1].....Rolla, Mo.
Burg, William.....4323 Washington Boul.
Burnett, E. C.....University Club.
Busch, Adolphus.....Busch Pl.
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Bush, Benjamin Franklin[1]...Courtney, Mo.
Butler, William M.....Yeatman High School.

Cale, George W., Jr.....12 Lennox Pl.
Campbell, James A.....Mermod Jaccard Bldg.
Carleton, Murray.....1135 Washington Ave.
Carpenter, George O.....12 Portland Pl.
Carr, Peyton T.....62 Vandeventer Pl.
Carter, Howard[1].....Webster Groves, Mo.
Carver, George Washington[1]..Tuskegee, Ala.
Caspari, Charles E.....4060 Westminster Pl.
Catlin, Daniel.....Security Bldg.
Chambers, C. O.....Missouri Botanical Garden.

Chappell, W. G.....Buckingham Club.
Chenery, Winthrop Holt.....Washington University.
Christie, Harvey L.....5544 Cabanne Pl.
Clarke, Enos[1].....Kirkwood, Mo.
Clopton, Malvern B.....Humboldt Bldg.
Cole, John J.....316 South Seventh St.
Colnon, R. S.....506 Merchants' Laclede Bldg.
Conzelman, Theophilus.....5260 Washington Boul.
Cook, Abraham.....4208 Pine St.
Cook, Francis E.....4398e Olive St.
Cook, Isaac T.....Chemical Bldg.
Cook, Jerome E.....4254 Lindell Boul.
Coulter, Samuel M.....Washington University.
Craig, Moses.....Missouri Botanical Garden.
Cramer, Gustav.....Care Cramer Dry Plate Co.
Crandall, George C.....3674 Lindell Boul.
Crawford, Hanford.....4442 Lindell Boul.
Crecelius, Elyse C.....1110 Dillon St.
Crook, A. R.[1].....State Natural History Museum, Springfield, Ill.
Cupples, Samuel.....3673 Pine St.
Curley, Francis E. A.....6143 Berlin Ave.
Curtis, Chester B.....Central High School.
Curtis, William S.....Washington University.

Dameron, Edward Caswell[1]....Clarksville, Mo.
Danforth, Charles H.....Washington University, Medical Department.
Davis, Dwight F.....220 Security Bldg.
Davis, H. N.....56 Vandeventer Pl.
Davis, John D.....815 Merchants' Laclede Bldg.
Dean, George R[1].....Rolla, Mo.
Densford, H. E.[1].....Kirkwood, Mo.
Dewey, Lyster H.[1].....4612 Ninth St., N. W., Washington, D. C.
Dieckmann, Charles A.....2816 Potomac St.
Diehm, Ferdinand.....6175 Kingsbury Pl.
Doan, George P.....42 Portland Pl.
Dock, George.....Washington University Medical Department.
Dorsett, Walter B.....Linmar Bldg.

Dougan, Lewis M.....Shaw School.
Drosten, F. W.....2011 Park Ave.
Drushel, J. A.....Teachers' College.
Duncan, John H.....Humboldt Bldg.
Duncan, M. E.....4630 Lindell Boul.
Duncker, Charles H.....3636 Page Ave.

Ebeling, A. W.[1].....Warrenton, Mo.
Eberle, E. G.[1].....416 Jackson St., Dallas, Texas.
Eimbeck, August F.[1].....New Haven, Mo.
Eliot, Edward C.....5468 Maple Ave.
Emerson, John B.....Syndicate Trust Bldg.
Emmel, Victor E.....Washington University, Medical Department.
Engler, Edmund Arthur.....Washington University.
Ericson, Eric John.....1420 Clara Ave.
Erker, Adolph P.....604 Olive St.
Espenschied, Charles.....3500 Washington Ave.
Euston, Alexander.....3730 Lindell Boul.
Evers, Edward.....1861 North Market St.
Ewing, Arthur E.....5956 West Cabanne Pl.

Farr, Henry V.....4916 Labadie Ave.
Fawcett, H. S.[1].....State Commission of Horticulture, Sacramento, Cal.
Ferriss, James H.[1].....Joliet, Ill.
Filley, John D.....40 Westmoreland Pl.
Fischel, Walter.....5284 Westminster Pl.
Fischel, Washington E.....Humboldt Bldg.
Fish, E. R.....2449 E. Marcus Ave.
Floyd, B. F.[1].....Gainesville, Fla.
Fordyce, John R.[1].....2223 Louisiana St., Little Rock, Ark.
Fordyce, S. W.....21 Washington Terrace.
Francis, David R.....4421 Maryland Ave.
Franck, Charles H.....Liggett Bldg.
French, George Hazen[1].....Carbondale, Ill.
Frerichs, Frederick W.....4320 Washington Boul.
Frick, John Henry[1].....Warrenton, Mo.
Fruth, Otto J.....3060 Hawthorne Boul.
Fry, Frank R.....4609 McPherson Ave.
Fuhrmann, Richard H.....3221 California Ave.

Fullgraf, Charles W.....7077 Pernod Ave.
Funkhouser, Robert Monroe..4354 Olive St.

Garman, Harrison[1].....Lexington, Ky.
Gecks, Frank.....3453 Magnolia Ave.
Geitz, H. A.[1].....17 West End Ave., Rockaway Park, Long Island, N. Y.
Gellhorn, George.....Metropolitan Bldg.
Gifford, William L. R.....Mercantile Library.
Gill, Charles M.....Teachers' College.
Gillette, C. P.[1].....Fort Collins, Colo.
Glasgow, Frank A.....3894 Washington Ave.
Glazebrook, Thomas B.....1606 Pine St.
Goldstein, Max A.....3858 Westminster Pl.
Goltra, Edward F.....4416 Lindell Boul.
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Greene, F. C., Jr.[1].....Rolla, Mo.
Greer, E. O.....2750 Park Ave.
Greger, Darling Kennett[1]....Westminster College, Fulton, Mo.
Gregg, Cecil D.....920 Market St.
Grindon, Joseph.....3894 Washington Ave.
Gundelach, William J.....4937 Forest Park Boul.
Gundlach, John H.....3615 North Broadway.
Guthrie, Robert J.....Pierce Bldg.
Guy, William E.....10 Portland Pl.

Haarstick, Henry C.....St. Louis Union Trust Bldg.
Hall, Fred B.....4579 Morgan St.
Hambach, Gustav[2].....Herford, Westphalia, Germany.
Hard, M. E.[1].....Kirkwood, Mo.
Harder, Ulrich.....8015 Florissant Ave.
Harms, L. A. P.[1].....Kirkwood, Mo.
Harris, James Arthur[1].....Station for Experimental Evolution, Cold Spring Harbor, Long Island, N. Y.

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[2] Elected a life-member January 3, 1882.

Hartmann, Rudolph.....3859 Flora Boul.
Hecker, Fredrick[1].....Argyle Bldg., Kansas City, Mo.
Held, George A.....International Bank.
Hendrich, Walter F.....6228 Washington Boul.
Herf, Oscar.....48 Gay Bldg.
Hidden, Edward.....Commonwealth Trust Bldg.
Hill, Charles Van Dyke.....Third National Bank Bldg.
Hoffman, Philip.....3657 Delmar Ave.
Hoke, William E.....304 North Third St.
Holman, C. L.....716 Locust St.
Holmes, J. A.....Tenth and Spruce Sts.
Hough, Warwick.....5884 Cates Ave.
Houwink, J. J.....Delmar Bldg.
Hughes, Charles Hamilton....Metropolitan Bldg.
Hughes, Marc Ray.....Metropolitan Bldg.
Hume, H. Harold[1].....Glen St. Mary, Fla.
Hurter, Julius.....2346 South Tenth St.
Hus, Henri Th. A.[1].....University of Michigan, Ann Arbor, Mich.
Huttig, Charles H.....Third National Bank.

Ilhardt, William K.....Euclid and Delmar Aves.
Irish, Henry C.....Missouri Botanical Garden.

Jensen, L. P.....Busch Pl.
Johnson, Albert L.[1].....Mutual Life Insurance Bldg., Buffalo, N. Y.
Jonas, Ernest.....465 North Taylor Ave.
Jones, Breckenridge.....45 Portland Pl.
Jones, Robert McKittrick.....6 Westmoreland Pl.

Kammerer, Alfred L.....Tower Grove and Flad Aves.
Keiser, Edward H.....Washington University.
Keller Joseph M.....3712 Westminster Pl.
Kennett, Luther M.....3507 Lucas Ave.
Kessler, George E.....529 Frisco Bldg.
Kessler, J. J.....224 South Vandeventer Ave.
Keyes, Charles R.[1].....944 Fifth St., Des Moines, Ia.
Kinealy, John H.....503 Granite Bldg.
King, Goodman.....78 Vandeventer Pl.
Kinsella, W. J.....4422 Lindell Boul.

Kirchner, Walter C. G.....1127 North Grand Ave.
Klem, Mary J.....3133 Nebraska Ave.
Knapp, H. P.....Eighteenth and Olive Sts.
Knight, H. F.....4433 Westminster Pl.
Knight, S. S.....6700 Manchester Ave.

La Brie, Joseph Damas.....404 Houston St., Kansas City, Mo.
Lang, George, Jr.....3601 Salena St.
Langsdorf, Alexander S.....Washington University.
Larkin, E. H.....109 St. George St.
Leavitt, Sherman[1].....Illinois College, Jacksonville, Ill.
Lee, James S.....City Hall.
Lefevre, George[1].....University of Missouri, Columbia, Mo.
Letterman, George W.[1].....Allenton, Mo.
Le Van, W. C.[1].....116 Taylor Ave., Kirkwood, Mo.
Lewis, E. G.[1].....University City, Mo.
Lichter, John J.....1740 Simpson Pl.
Lloyd, Francis Ernest[1].....Alabama Polytechnic Institute, Auburn, Ala.
Lloyd, Hiram.....Odd Fellows' Bldg.
Loeb, Hanau Wolf.....Humboldt Bldg.
Loeb, Leo.....St. Louis Skin and Cancer Hospital.
Luedde, William H.....Metropolitan Bldg.
Lukens, C. DeWitt.....4908 Laclede Ave.
Lutz, Frank J.....Josephine Hospital.

MacDougal, D. T.[1].....Tucson, Ariz.
Mack, Charles Jacob.....113 North Broadway.
Mallinckrodt, Edward, Jr.....Mallinckrodt Chemical Works.
Mardorf, W. C.....2136 South Grand Ave.
Markham, George Dickson...4961 Berlin Ave.
Mason, Silas C.[1].....R. F. D. No. 1, Bethesda, Md.
Matthews, Leonard.....5447 Cabanne Pl.
Mauran, John Lawrence.....1620 Chemical Bldg.
McBride, W. J.[1].....Haskell & Barker Car Co., Michigan City, Ind.
McCourt, Walter Edward.....Washington University.

McCubbin, J. B.....Metropolitan Bldg.
McCulloch, Richard.....3869 Park Ave.
McCulloch, Robert.....3869 Park Ave.
McKittrick, Thomas H.....911 Washington Ave.
McLeod, N. W.....Lumbermen's Bldg.
Meier, Theodore G.....5220 Washington Boul.
Mesker, Frank.....421 South Sixth St.
Meyer, Jesse S.....3894 Washington Boul.
Michael, Elias.....Rice, Stix Dry Goods Co.
Middleton, Thomas[1].....Webster Groves, Mo.
Mitchell, E. T.[1].....7730 Jeanette St.,
New Orleans, La.
Monell, Joseph T.....3454 Halliday Ave.
Moore, George T.....Missouri Botanical Garden.
Moore, Philip N.....Merchants' Laclede Bldg.
Moore, Robert.....61 Vandeventer Pl.
Morfit, John Campbell.....3534 Washington Ave.
Morrison, Gilbert B.....McKinley High School.
Morse, Sidney[1].....University City, Mo.
Mudd, Harvey G.....408 Humboldt Bldg.
Mueller, Ambrose[1].....Webster Groves, Mo.
Mumford, Frederick B.[1].....Columbia, Mo.

Nagel, Charles.....3726 Washington Boul.
Nasse, August.....2323 Lafayette Ave.
Nauer, Albert R.....4634 Nebraska Ave.
Nicolaus, Henry.....2149 South Grand Ave.
Nipher, Francis E.....Washington University.
Nisbet, Fritz.....611 Locust St.
Noel, Alexander H.....1323 Geyer Ave.
Nolker, William H.....Fifteenth and Pine Sts.
Norvell, Saunders.....LaSalle Bldg.

Ohlweiler, W. W.....4026a Shenandoah Ave.
Olshausen, Ernest P.....1115 Rutger St.
Opie, Eugene L.....Washington University,
Medical Department.
O'Reilly, Andrew J.....1720 Pierce Bldg.
O'Reilly, Robert J.....27 Washington Terrace.

Padberg, Aloys J.....3900a Easton Ave.
Palmer, Ernest Jesse[1].....321 S. Allen St.,
Webb City, Mo.

Pammel, Louis Hermann[1]....Ames, Iowa.
Pantaleoni, Guido.....15 Lennox Pl.
Parker, George Ward[1].....45 Broadway, New York City.
Parker, L. S.[1].....Jefferson City, Mo.
Payne, E. G.....Teachers' College.
Pennock, C. J.[1].....Kennett Square, Chester Co., Pa.
Perkins, Albert T.....401 North Fourth St.
Pettus, Charles P.....33 Westmoreland Pl.
Pettus, W. H. H.....4373 Westminster Pl.
Pitzman, Julius.....1900 South Compton Ave.
Plant, Frederick S.....802 North Main St.
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Post, Martin Hayward.....5371 Waterman Ave.
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Pyle, Lindley.....6116 Washington Boul.

Randolph, Tom.....7 Kingsbury Pl.
Rassieur, Leo.....Fourth and Market Sts.
Rathmann, Charles G.....3886 Hartford St.
Rau, Philip.....4932 Botanical Ave.
Ravold, Amand.....5248 Vernon Ave.
Reber, H. Linton.....Kinloch Bldg.
Reber, Maxime.....301 New City Hall.
Reed, George M.[1].....809 Virginia Ave., Columbia, Mo.
Reller, A. H.....24 Gast Pl.
Ricker, Maurice[1].....1039 Nineteenth St. Des Moines, Iowa.
Robarts, Heber.....5899 Cates Ave.
Robbins, Walter.....6400 Plymouth Ave.
Roever, William Henry.....Washington University.
Rolfs, F. M.[1].....Mountain Grove, Mo.
Rolfs, Peter H.[1].....Gainesville, Fla.
Rose, Hugh B.....401 North Fourth St.
Rosenwald, Lucian[1].....412 Delaware St., Kansas City, Mo.
Rowse, E. C.....Chemical Bldg.
Ruf, Frank A.....5863 Cabanne Pl.

Rusch, Henri.....City Hall.
Ryan, Frank K.....Times Bldg.

Sampson, C. L.....3029 Eads Ave.
Sampson, Francis A.[1].....Columbia, Mo.
Sargent, Charles Sprague[1].....Jamaica Plains, Mass.
Sauer, William E.....Humboldt Bldg.
Scanlan, Philip C.....4450 Lindell Boul.
Schisler, Edwin.....2600 South Grand Ave.
Schlueter, Robert E.....909 Park Ave.
Schmidt, Louis.....Franklin Bank.
Schnell, L. W.....4541 Varrelmann St.
Schramm, Jacob.....Missouri Botanical Garden.
Von Schrenk, Hermann.....Tower Grove and Flad Aves.
Schrowang, Otto.....Panama Bldg.
Schuricht, A. G.....3236 Lafayette Ave.
Schwarz, Ernest.....6310 Newstead Ave.
Schwarz, Frank.....1813 Lafayette Ave.
Schwarz, Henry.....440 North Newstead Ave.
Schwarz, Herman[1].....720 Clark Ave.,
Webster Groves, Mo.
Schweyer, George.....4252 Blaine Ave.
See, Thomas Jefferson Jackson[1].Naval Observatory,
Mare Island, Cal.
Selby, Augustine Dawson[1]....Wooster, Ohio.
Senseney, E. M.....5738 Clemens Ave.
Senter, Charles Parsons.....1 Beverly Pl.
Sexton, L. J. .....Madison School.
Shaffer, Philip A.....Washington University,
Medical Department.
Shahan, William E.....5234a Morgan St.
Shannon, James I.....St. Louis University.
Shapleigh, Alfred Lee.....3636 Delmar Ave.
Shapleigh, John B.....Humboldt Bldg.
Sheldon, F. E.....Chemical Bldg.
Shepley, John F.....50 Vandeventer Pl.
Shimek, B.[1].....Iowa City, Iowa.
Shoemaker, William Alfred...4386 Westminster Pl.
Shutt, C. H.....Metropolitan Bldg.
Simmons, E. C.....Ninth and Spruce Sts.
Simmons, Wallace D.....Ninth and Spruce Sts.

Skinker, Thomas K.....Pierce Bldg.
Sluder, Greenfield.....3542 Washington Ave.
Smith, Arthur George[1].....Iowa City, Iowa.
Smith, D. S. H.....4388 Westminster Pl.
Smith, George M.....Washington University, Medical Department.
Smith, Irwin Z.....87 Vandeventer Pl.
Smith, Jared G.[1].....Kealakekua, Hawaiian Islands.
Spencer, H. N.....2725 Washington Ave.
Standley, Paul C.[1].....Division of Plants, National Museum, Washington, D. C.
Starkloff, H. M.....3623 Cleveland Ave.
Starr, John E.[1].....50 Church St., New York City.
Staudinger, B.....3556 Lindell Boul.
Stelzleni, G. M.....1215 North Grand Ave.
Stennett, W. H.[1].....203 Linden Ave., Oak Park, Cook Co., Ill.
Stevens, Charles D.....948 Laurel Ave.
Stevens, Wyandotte James....4448 Olive St.
Stindé, George C.....5146 McPherson Ave.
Stix, Charles A.....Stix, Baer & Fuller Dry Goods Company.
Stocker, George J.....2833 South Kingshighway Bl.
Strecker, John K., Jr.[1].....Baylor University, Waco, Tex.
Sultan, Fred W.....112 North Second St.
Summa, Hugo.....Metropolitan Bldg.
Suppan, Leo.....2648 Russell Ave.

Taussig, William.....3447 Lafayette Ave.
Terry, Robert James.....Washington University, Medical Department.
Thacher, Arthur.....5185 Lindell Boul.
Thomas, John R.....4128 Washington Boul.
Thomasson, Hugh W.....Grand and Delmar Aves.
Thompson, Charles Henry...Missouri Botanical Garden.
Thompson, Frank C.[1].....522 Big Bend Road, Webster Groves, Mo.
Thompson, Henry C., Jr.....4642 Cook Ave.
Thurman, John S.....521 North Taylor Ave.
Timmerman, Arthur H.....6400 Plymouth Ave.
Tittmann, Harold H.....5024 Westminster Pl.
Todd, Charles A.....3723 Delmar Ave.

Trelease, William.....Missouri Botanical Garden.
Tuholske, Herman.....465 North Taylor Ave.
Turner, Charles H.....Sumner High School.
Turner, Wilson P. H.....411 Olive St.
Tuttle, Daniel S.....74 Vandeventer Pl.

Van Ornum, John Lane.....Washington University.
Vickroy, Wilhelm Rees.....2901 Rauschenbach Ave.

Walbridge, C. P.....Fourth and Market Sts.
Waldo, C. A.....Washington University.
Wallace, G. W.[1].....532 Lee Ave.,
Webster Groves, Mo.
Walsh, Julius S.....Fourth and Pine Sts.
Watts, Millard F.....5740 Cabanne Pl.
Weichsel, Hans.....6400 Plymouth Ave.
Weiss, Adolph M.....421 North Fourth St.
Wells, Rolla.....4228 Lindell Boul.
Werner, Louis.....Fullerton Bldg.
Werner, Percy.....5505 Cates Ave.
Wheeler, H. A.....3439 Lucas Ave.
Whelpley, Henry Milton.....2342 Albion Pl.
Whitaker, Edwards.....300 North Fourth St.
Whitelaw, George G.....5825 Cates Ave.
Whitelaw, Oscar L.....409 North Second St.
Whitten, John Charles[1].....Columbia, Mo.
Widmann, Otto.....5105 Morgan St.
Wiedemann, H. E.....721 Holland Bldg.
Wielandy, Paul J.....Sixteenth and Locust Sts.
Wiener, Meyer.....3854 Westminster Pl.
Wiggins, Charles.....32 Vandeventer Pl.
Wilson, M. E.....Washington University.
Winkelmeyer, Christopher....4585 West Pine St.
Wislizenus, Frederick A.....Washington University.
Witt, Thomas D.....4374 Laclede Ave.
Wolf, Alexander S.....Century Bldg.
Wolfner, Henry L.....4563 Forest Park Boul.
Woodward, Calvin Milton.....3013 Hawthorne Boul.
Woodward, Walter B.....Woodward & Tiernan Ptg. Co.
Wright, George M.....4457 Westminster Pl.

Zahorsky, John.....1460 South Grand Ave.
Zellweger, John.....1900 Adelaide Ave.

ABSTRACT OF HISTORY.

ORGANIZATION.

The Academy of Science of St. Louis was organized on the 10th of March, 1856, in the hall of the Board of Public Schools. Dr. George Engelmann was the first President.

CHARTER.

On the 17th of January following, a charter incorporating the Academy was signed and approved, and this was accepted by a vote of the Academy on the 9th of February, 1857.

OBJECTS.

The act of incorporation declares the object of the Academy to be the advancement of science and the establishment in St. Louis of a museum and library for the illustration and study of its various branches, and provides that the members shall acquire no individual property in the real estate, cabinets, library, or other of its effects, their interest being merely usufructuary.

The constitution as adopted at the organization meeting and amended at various times subsequently, provides for holding meetings for the consideration and discussion of scientific subjects; taking measures to procure original papers upon such subjects; the publication of transactions; the establishment and maintenance of a cabinet of objects illustrative of the several departments of science and a library of works relating to the same; and the establishment of relations with other scientific institutions. To encourage and promote special investigation in any branch of science, the formation of special sections under the charter is provided for.

MEMBERSHIP.

Members are classified as active members, corresponding members, honorary members and patrons. Active membership is limited to persons interested in science, though they need not of necessity be engaged in scientific work, and they alone conduct the affairs of the Academy, under its constitution. Persons not living in the city or county of St. Louis who are disposed to further the objects of the Academy, by original researches, contributions of specimens, or otherwise, are eligible as corresponding members. Persons not living in the city or county of St. Louis are eligible as honorary members by virtue of their attainments in science. Any person conveying to the Academy the sum of one thousand dollars or its equivalent becomes eligible as a patron.

Under the By-Laws, resident active members pay an initiation fee of five dollars and annual dues of six dollars. Non-resident active members pay the same initiation fee, but annual dues of three dollars only. Patrons and honorary and corresponding members are exempt from the payment of dues. Each patron and active member not in arrears is entitled to one copy of each publication of the Academy issued after his election.

Since the organization of the Academy, 1,307 persons have been elected to active membership, of whom, on December 31, 1911, 425 were carried on the list. Six patrons, Mr. Edwin Harrison, Mrs. Eliza McMillan, Mr. William Northrop McMillan, Mr. Henry W. Eliot, Mr. William Keeney Bixby and Mr. Edward Mallinckrodt, have been elected. Elections to honorary membership number 19 (page vi), and 226 persons (Vol. X., p. xii) have been elected to corresponding membership.

OFFICERS AND MANAGEMENT.

The officers, who are chosen from the active members, consist of a President, two Vice-Presidents, Recording and Corresponding Secretaries, Treasurer, Librarian,

three Curators and two Directors. The general business management of the Academy is vested in a Council composed of the officers.

The office of President has been filled by the following well-known citizens of St. Louis, nearly all of whom have been eminent in some line of scientific work: George Engelmann, Benjamin F. Shumard, Adolphus Wislizenus, Hiram A. Prout, John B. Johnson, James B. Eads, William T. Harris, Charles V. Riley, Francis E. Nipher, Henry S. Pritchett, John Green, Melvin L. Gray, Edmund A. Engler, Robert Moore, Henry W. Eliot, Edwin Harrison, Adolf Alt, Calvin M. Woodward, and William Trelease.

MEETINGS.

The regular meetings of the Academy are held at its building, 3817 Olive Street, at 8 o'clock, on the first and third Monday evenings of each month, a recess being taken between the meeting on the first Monday in June and the meeting on the third Monday in October. These meetings, to which interested persons are always welcome, are devoted in part to the reading of technical papers designed for publication in the Academy's Transactions, and in part to the presentation of more popular abstracts of recent investigation or progress. From time to time public lectures, calculated to interest a larger audience, are provided for in some suitable hall.

The following dates for regular meetings for the year 1912 have been fixed by the Council:

Jan	Feb	Mar	April	May	June	Oct	Nov	Dec
	5	4	1	6	3		4	2
15	19	18	15	20		21	18	16

LIBRARY.

After its organization, the Academy met in Pope's Medical College, where a creditable beginning had been made toward the formation of a museum and library, until May, 1869, when the building and museum were destroyed by fire, the library being saved. The library now contains about 18,500 books and 16,000 pamphlets, and is open during certain hours of the day for consultation by members and persons engaged in scientific work.

PUBLICATIONS AND EXCHANGES.

Twenty octavo volumes of Transactions have been published since the organization of the Academy, and widely distributed. Two quarto publications have also been issued: one from the Archaeological Section, being a contribution to the archaeology of Missouri, and the other a report of the observations made by the Washington University Eclipse Party of 1889. The Academy now stands in exchange relations with 415 institutions or organizations of aims similar to its own.

MUSEUM.

After the loss of its first museum, in 1869, the Academy lacked adequate room for the arrangement of a public museum, and, although small museum accessions were received and cared for, its main effort, of necessity, was concentrated on the holding of meetings, the formation of a library, the publication of worthy scientific matter, and the maintenance of relations with other scientific bodies.

The Museum is at present located on the third floor of the Academy Building and has in it a number of specimens illustrating the various branches of natural science, among which may be mentioned the Yandell Collection of fossils, a collection of some 600 exotic butterflies, a collection of Mound Builder pottery and skulls from near New Madrid, Mo., and a collection of 25 meteorites. Our material forms but a nucleus of a museum which the Academy hopes to establish—a museum which we trust will be of benefit to the public and to the educational institutions of the city.

RECORD.

From January 1 to December 31, 1911.

The following list of papers were presented at the meetings during this period:

January 16, 1911:

Francis E. Nipher.—Nature of an Electric Discharge.

(Published in Transactions of The Academy of Science of St. Louis, Vol. XX, No. 1, 1911.)

February 6, 1911:

William Trelease.—An Account of the Desert Genus Nolina.

(A partial progress report on a study, the results of which in full were published under the title, "The Desert Group Nolineae," in the Proceedings of the American Philosophical Society, Vol. L, 1911.)

February 20, 1911:

James Newton Baskett.—Some Delusions Concerning the Economic Value of Birds.

(Published in Scientific American, Vol. CIII, Nov. 12, 1910.)

March 6, 1911:

Malcolm E. Wilson.—Some Geological Features in the Yellowstone National Park.

March 20, 1911:

J. Andrew Drushel.—Studies in Glacial Geology in Saint Louis and Vicinity.

(Published in Transactions of The Academy of Science of St. Louis, Vol. XX, No. 3, 1911.)

Francis E. Nipher.—An Interesting Optical Illusion.

(Published in Proceedings of The American Philosophical Society, Vol. L, 1911.)

April 3, 1911:

LEO LOEB.—The Parthenogenetic Development of the Ova in the Mammalian Ovary.
(Published in Archiv für Entwicklungsmechanik, Bd. XXXII, Nov. 21, 1911, and in Zeitschrift für Krebsforschung, Bd. XI, Sept. 2, 1911.)

H. A. WHEELER.—Oil Fields in Illinois.
(Published 1911.)

EDMUND A. ENGLER.—Figurate Numbers.
(Published in Transactions of The Academy of Science of St. Louis, Vol. XX, No. 4, 1911.)

April 17, 1911:

C. A. WALDO.—The London Tubes.

May 1, 1911:

THOMAS J. J. SEE.—Recent Discoveries in Cosmogony.
(Published in Scientia, Milan, Jan., 1912.)

May 15, 1911:

HENRI T. A. HUS.—The Origin of Species in Nature.
(Published in American Naturalist, Vol. XLV, Nov., 1911.)

June 5, 1911:

C. M. WOODWARD.—The Theory of an Air Propeller with Haelicoidal Blades.
(Published in Applied Mechanics, 1912.)

GEORGE A. LINDSAY.—The Annual Rainfall and Temperature of the United States.

October 16, 1911:

FRANCIS E. NIPHER.—Electricity and Matter.

November 6, 1911:

J. J. KESSLER.—Interpolation Method of Oil Analysis.
(Published in Journal of Industrial and Engineering Chemistry, Feb., 1911.)

November 20, 1911:

James F. Abbott.—An Examination of Poulton's Theory of Mimicry.

December 4, 1911:

William H. Roever.—The Southerly Deviation of Falling Bodies.

(Published in Transactions of The American Mathematical Society, Vol. XII, No. 3, 1911.)

W. A. Murrill.—Experiences Collecting Fungi in Many Lands.

December 18, 1911:

Chas. H. Thompson.—Interesting Hybrids.

Francis E. Nipher.—Electric Experiments in the Study of Solutions.

William Trelease.—Mistletoes of North America.

Meeting of January 16, 1911.

The Academy of Science of St. Louis met in the Academy Building, 3817 Olive Street, at 8 p. m., January 16, 1911; President Trelease in the chair; attendance 15.

The President delivered his address as President of the Academy for the year 1910.[3]

The Treasurer's report for the year 1910 was submitted.[4]

The report of the Curators for 1910 was read.[5]

The report of the Librarian for 1910 was presented.[6]

The report of the Entomological Section was submitted.[7]

The Nominating Commitee reported the results of the election of officers for 1911, as follows:

President	William Trelease
First Vice-President	D. S. H. Smith
Second Vice-President	F. E. Nipher
Recording Secretary	Walter E. McCourt
Corresponding Secretary	Geo. T. Moore
Treasurer	H. E. Wiedemann
Librarian	Wm. L. R. Gifford
Curators	Julius Hurter
	Joseph Grindon
	Philip Rau
Directors	Otto Widmann
	Adolf Alt

Professor F. E. Nipher spoke of his latest experiments on the Nature of the Electric Discharge.

Mr. E. R. Fish and Dr. Alexander S. Wolf were elected to membership.

February 6, 1911.

President Trelease in the chair; attendance 31.

Professor William Trelease gave an account of "The Desert Genus *Nolina*," illustrated with lantern slides.

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[3] Transactions, Vol. XIX, page xxxvi.
[4] Transactions, Vol. XIX, page xxxviii.
[5] Transactions, Vol. XIX, page xxxix.
[6] Transactions, Vol. XIX, page xxxix.
[7] Transactions, Vol. XIX, page xxxix.

Messrs. James S. Lee and L. S. Parker were elected to membership.

February 20, 1911.

President Trelease in the chair; attendance 45.

Mr. James Newton Baskett addressed the Academy on "Some Delusions Concerning the Economic Value of Birds."

The following were elected to membership: J. C. Branner, James E. Brock, Leo Loeb, A. G. Schuricht and Geo. W. Wallace.

March 6, 1911.

President Trelease in the chair; attendance 47.

Mr. Malcolm E. Wilson gave an illustrated account of "Some Geological Features in the Yellowstone National Park."

Mr. Geo. G. Whitelaw was elected to membership.

March 20, 1911.

President Trelease in the chair; attendance 50.

Mr. J. Andrew Drushel gave an illustrated account of his "Studies in Glacial Geology in St. Louis and Vicinity."

Professor F. E. Nipher spoke on "An Interesting Optical Illusion."

Mr. C. L. Sampson was elected to membership.

The death of Professor J. W. Van't Hoff, an honorary member, and of Dr. Wm. B. Outten, an active member, was announced.

April 3, 1911.

President Trelease in the chair; attendance 30.

Dr. Leo Loeb presented a paper entitled "The Parthenogenetic Development of the Ova in the Mammalian Ovary."

Mr. H. A. Wheeler spoke on the "Oil Fields of Illinois."

Dr. Edmund A. Engler presented a paper entitled "Figurate Numbers."

The death of Judge Wilbur F. Boyle and of Dr. Noah M. Glatfelter was announced.

April 17, 1911.

Vice-President Nipher in the chair; attendance 26.

Professor C. A. Waldo presented a paper, illustrated by diagrams and sections, on "The London Tubes."

Messrs. Alexander H. Noel and L. J. Sexton were elected to membership.

May 1, 1911.

President Trelease in the chair; attendance 150.

Professor Thomas Jefferson Jackson See, of the Naval Observatory at Mare Island, California, delivered an address on "Recent Discoveries in Cosmogony."

Mr. Hugh W. Thomasson was elected to membership.

May 15, 1911.

President Trelease in the chair; attendance 30.

Mr. Henry W. Anderson read a paper by Mr. H. T. A. Hus, of the University of Michigan, on "The Origin of Species in Nature."

Mr. Adolphe M. Weiss was elected to membership.

The death of Professor Halsey Cooley Ives was reported.

June 5, 1911.

President Trelease in the chair; attendance 15.

Professor C. M. Woodward addressed the Academy on "The Theory of an Air Propeller with Haelicoidal Blades."

Mr. George A. Lindsay read a paper on "The Annual Rainfall and Temperature of the United States."

October 16, 1911.

President Trelease in the chair; attendance 45.

Dr. Adolf Alt presented to the museum a specimen of *Haliotis tuberculata* from California.

Professor F. E. Nipher gave a most interesting lecture on Electricity and Matter, reviewing his recent work on the electric discharge.

The death of Professor Paul Schweitzer was reported.

November 6, 1911.

Vice-President Nipher in the chair; attendance 14.

Dr. J. J. Kessler presented a paper entitled "Interpolation Method of Oil Analysis."

The following were elected to membership: Elyse C. Crecelius, B. F. Floyd, L. A. P. Harms, Frederick Hecker, L. P. Jensen, S. S. Knight, Philip N. Moore, Frederick B. Mumford, Francis A. Sampson, M. E. Wilson and Walter B. Woodward.

The death of Professor Theodore Escherich, an honorary member, and of Dr. Chas. H. Gundelach, an active member, was reported.

November 20, 1911.

Vice-President Nipher in the chair; attendance 23.

Professor James F. Abbott presented an interesting paper on "An Examination of Poulton's Theory of Mimicry."

The following were elected to membership: Robert H. Baker, F. C. Greene, Jr., Thomas K. Skinker, Joseph Damas LaBrie, Ada E. Plass and George M. Smith.

December 4, 1911.

President Trelease in the chair; attendance 24.

Professor Wm. H. Roever presented a paper on "The Deviation of Falling Bodies."

Professor Murrill, of the New York Botanical Garden, spoke of some of his experiences collecting Fungi in many lands.

Mr. Frank Schwarz, Professor C. A. Waldo and Mr. J. Andrew Drushel were elected to serve as a committee to nominate officers for the year 1912.

December 18, 1911.

President Trelease in the chair; attendance 48.

The St. Louis Chemical Society presented to the Academy a series of chemical publications. These were accepted, and the Secretary authorized to communicate the thanks of the Academy for the gift.

The following report from the Nominating Committee was read:

St. Louis, Mo., Dec. 18, 1911.

Academy of Science of St. Louis,
St. Louis, Mo.

Gentlemen:—

The nominating committee, appointed at the meeting of December 4th, beg to submit the following nominees for offices for the year 1912:

For President	Edmund A. Engler
For First Vice-President	Francis E. Nipher
For Second Vice-President	Arthur E. Ewing
For Recording Secretary	M. E. Hard
For Corresponding Secretary	George T. Moore
For Treasurer	H. E. Wiedemann
For Librarian	Wm. L. R. Gifford
For Curators	Julius Hurter
	Joseph Grindon
	Phil Rau
For Directors	Otto Widmann
	Adolf Alt

Respectfully submitted,

(Signed) F. SCHWARZ,
C. A. WALDO,
J. A. DRUSHEL.

Mr. C. H. Thompson exhibited and explained some very interesting hybrids which he had been cultivating.

Professor F. E. Nipher gave a brief account of some recent results obtained in electrical experiments in the study of solutions.

Dr. Wm. Trelease presented in most interesting form an illustrated account of the "Mistletoes of North America."

Dr. Aloys J. Padberg was elected to membership.

The death of Mr. Edward S. Robert was reported.

REPORTS OF OFFICERS.

President's Address.

Fellow Members:

The Academy closes its fifty-fifth year with a record on which we may exchange congratulations and from which we may learn something.

Fifteen meetings have been held with an average attendance of 36. The papers presented have been of general and varied interest covering the field of astronomy; botany—with analyses of certain phases of evolution, hybridization and variation; chemistry; engineering; geology—including an important study of glaciation, and an analysis of the petroleum supply of the country; mathematics; meteorology, comparatively treated; physics—along the line of electrical experimentation and the mechanics of aviation; physiology; and zoology—including economic ornithology and the interesting field of mimetic variations. The Entomological Section has held five meetings, with an average attendance of 11, in addition to those of the Academy as a whole.

Though only six in number, the scientific brochures published during the year have been of unusual interest: F. E. Nipher, The Nature of the Electric Discharge; C. H. Thompson, Four New Plants from Mexico; J. A. Drushel, Studies in Glacial Geology in St. Louis and Vicinity; E. A. Engler, Figurate Numbers; Julius Hurter, The Herpetology of Missouri,—an exhaustive monograph; and Philip Rau, Sexual Selection Experiments on the Cecropia Moth, and Further Observations on Copulation and Oviposition in Samia cecropia, Linn. In addition to these papers, which, with the customary membership roster, abstract of proceedings, etc.—soon to be issued—will form the twentieth volume of the Academy's Transactions, a similar fascicle complementary to the nineteenth volume was printed early in the year.

Death has again claimed a large toll from the Academy's membership: Professors Escherich and Van't Hoff—honorary members; and Judge W. F. Boyle, Dr. N. M. Glatfelter, Dr. Charles H. Gundelach, Professor Halsey C. Ives, Dr. W. B. Outten, Mr. E. S. Robert, and Professor Paul Schweitzer,—active members. The Academy closes the year with two less active members than were carried on the list at its beginning; but 425 active members are now enrolled. Your continued interest is necessary if the membership is to be sustained at this level—which is essential; energetic effort, if made, will and should increase the membership to 500 in the year now opening.

In passing to another the responsibilities of an office with which you have honored me for the past three years, I avail myself of this opportunity to thank you collectively and individually for the personal co-operation and aid which alone have brought the Academy to its present satisfactory condition as respect membership, productive

scientific activity, efficiency in the popular presentation of the achievements of science, and financial solvency. If I speak of the last named topic, it is to bespeak for my successor in the presidency—long-tried and never found wanting in the Academy's service—the same shoulder-to-shoulder co-operation with which you have favored me, in order that our growing needs may be met by corresponding revenue, income and output being now balanced. To his initiative, if you grant him this support, we may safely look for an increase in the efficiency and usefulness of an institution which enjoys greater opportunities for usefulness today than when its founders organized it over half a century ago, or at any period of its always honorable and useful career.

(Signed) WILLIAM TRELEASE,
President.

Treasurer's Report.

Receipts.

Balance from 1910	$ 119.04
Dues from members	1,884.00
Rent from tenant societies	585.00
Telephone (Engineers' Club)	10.00
Academy's Transactions sold	98.33
Interest on balance, September, 1911	11.77
Julius Hurter (toward printing paper)	250.00
Refund from Laclede Gas Light Co	.03
Income from endowment fund	809.34
Total receipts for the year	$3,767.51

Expenditures.

Salaries	$1,190.00
Water license	13.00
Gas and electric light	112.92
Fuel	255.69
Telephone	58.25
Printing	1,526.69
Current expenses	416.12
Fire insurance (5 years)	168.00
Total expenditures for the year	$3,740.67
Balance December 31, 1911	26.84
	$3,767.51

Respectfully submitted,

(Signed) H. E. Wiedemann,
Treasurer.

Librarian's Report.

The Librarian reported that the accessions to the library for the year 1911 by exchange with 114 home and 301 foreign societies amounted to 634 volumes and 126 pamphlets, and by donation 78 volumes and 80 pamphlets.

The Transactions for the year were sent to 114 home and 301 foreign societies.

Curator's Report.

The Curators reported that during the year donations were received from:

Dr. Adolf Alt, a fine specimen of *Haliotis tuberculata* from California.

Report of the Entomological Section.

Tuxedo Park, Dec. 31, 1911.

To The Academy of Science of St. Louis:

The Entomological Section has held five meetings during the year 1911.

The papers presented at these meetings were as follows:

Professor J. F. Abbott—An examination of Poulton's Theory of Mimicry.

Hermann Schwarz—A collecting trip through St. Louis and Jefferson Counties, Missouri.

Ernst Schwarz—The genus Catocala.

Philip Rau—Sexual selection in the Cecropia moth.

J. T. Monell—Abnormal Aphids.

The average attendance at these meetings was five members and six visitors.

Respectfully submitted,

(Signed) Hermann Schwarz.
Secretary.

Transactions of The Academy of Science of St. Louis.

VOL. XX. No. 1.

NATURE OF THE ELECTRIC DISCHARGE.

FRANCIS E. NIPHER.

Issued February 28, 1911.

PUBLICATIONS.

The following publications of the Academy are offered for sale at the net prices indicated. Applications should be addressed to The Librarian, The Academy of Science of St. Louis, 3817 Olive St., St. Louis, Mo.

TRANSACTIONS (in octavo).

Vol.	Number.	Price per number.	Price per vol.	Price in set.
1	1* 2† 3, 4	..... $4.00 2.00 each.	$7.50 (Nos. 2–4 only.)	$7.00 (Nos. 2–4 only.)
2	1 to 3	2.00 each.	5.50	5.00
3	1 to 4	2.00 each.	7.50	7.00
4	1 to 4	2.00 each.	7.50	7.00
5	1–2, 3–4	4.00 each. (double numbers)	7.50	7.00
6‡	1, 2, 6, 8, 10, 11, 16, 17 4, 5, 7, 13, 14, 15, 18 3, 9 12	25 cts. each. 50 cts. each. 75 cts. each. $1.00	7.50	7.00
7‡	2, 3, 4, 6, 7, 8, 13, 15, 16, 18, 19 5, 9 to 12, 14, 20 17 1	25 cts. each. 50 cts. each. 75 cts. $1.00	7.50	7.00
8‡	1, 3 to 6 8, 10, 12 2, 7, 9, 11	25 cts. each. 50 cts. each.	3.75	3.50
9‡	1, 3, 4, 7, 9 2, 5, 8 6	25 cts. each. 50 cts. each. $1.25	3.75	3.50

Continued on page 3 of Cover.

NATURE OF THE ELECTRIC DISCHARGE.

Francis E. Nipher.

In the former paper, published as No. 4 of Vol. XIX, a reference to Figs. B and C of Plate XXV was made on pp. 67-8. The arrangement of the circuit was as shown in Fig. 2, p. 64, the copper plate having been removed. Fig. 2 is here reproduced as Fig. 1, for further reference.

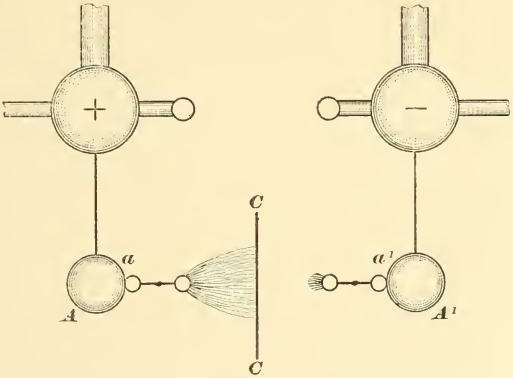

Fig. 1.

The suggestion made in the former paper that oscillations played an important part in determining such changes in form as are represented in Figs. B and C has been given additional attention. Incidentally the effect of such oscillations in promoting discharge is illustrated, although this is a phenomenon which has long been known.

Continued from Nos. 1 and 4, Vol. XIX. Presented before the Academy of Science of St. Louis, January 16th, 1911.

Figs. A and B, Plate I, of this paper, have been produced in the same manner as Figs. B and C of the former paper, excepting that the copper plate was not removed. There was a small hole through the copper plate, which permitted a small section of the positive column to pass through, but this did not affect the form of that part of the column which was cut off.

It appears from recent work that the form of the discharge streamers across the main gap to the copper plate or to the negative terminal, if the plate is removed, is determined mainly by the width of the two gaps *a* and *a'*, in the approach lines. In these gaps there is a continuous surging to and fro of air molecules. It is evidently a time alternation of convection and conduction discharge. In the one case the negative corpuscles are carried across the gap by super-charged molecules. This is a dark discharge. When these molecules return they have lost not only the excess but a part of their own normal charges. They then form a conductor, through which a luminous transfer by conduction takes place. These vibrations show their presence by musical tones of high pitch. The pitch of these notes rises as the gaps *a* and *a'* are made shorter. The sounds cease when these gaps are closed. In Fig. *A* of Plate I, a minute gap of less than a mm. existed in the negative approach line at *a'*. In B this gap was closed and a similar gap was made at *a* in the positive line. In Fig. C, both gaps were closed. In each case a flash light was used at the end of a five-minute exposure, in order to secure an image of the knobs. The diameter of the knobs was 1.8 cm.

When both gaps *a* and *a'* are closed and the lines leading from the machine terminals to the main gap are metallic throughout, as in Fig. C of Plate I, an active negative glow exists in front of the negative knob. The mica windmill, described in the last paper, shows that the air is being urged across the dark space to the copper plate. In the gap between the copper-plate and the positive knob, there were no luminous streamers, but they

formed when the windmill was placed in this gap, and a faint motion of the air towards the copper plate was then shown by the windmill.[1]

In Fig. C, a strongly marked glow is shown on the surface of the positive knob. It covers the hemisphere which faces the copper plate. This glow differs from the negative glow at the other knob. It gives the front of the knob the appearance of being at a red heat. Scintillations are occasionally visible over this luminous surface. They are perhaps the beginnings of drainage streamers. It seems evident that air molecules in contact with this luminous part of the knob are delivering corpuscles to the knob, but the drainage luminescence does not extend beyond the layer in close contact with the knob. If the contacts at either *a* or *a'* are disturbed so that any luminous effects exist at these gaps, this positive glow partly or wholly disappears and one or more luminous streamers shoot out from the positive knob, as in Fig. A. The drainage inflow to the positive terminal is then through and along these conducting channels. If the gap at *a* in the positive line is slightly increased in length, the luminous streamers appear in arc-like forms from points around the central line of discharge, as is seen in Fig. B. These streamers are continually vibrating as is the case when convection and conduction winds in opposite directions exist side by side. Fig. B of Plate I shows that these luminous conduction streamers have their origin at the positive knob, in zones which are concentric with the central axis through the two knobs. In the air around the discharge gap, these streamers apparently lie in co-axial cones, having dark spaces sandwiched between them. In these dark spaces the air is evidently drifting towards the positive knob, and into the luminous streamers on either side, where the conduction transfer is taking place, and where the air molecules are moving away from the positive knob. The action is similar to

[1] The front edge of the plate is not in focus, and its image is rather imperfectly reproduced in the original, and does not appear in this figure.

the discharges across a gap shorter than the critical spark length as discussed in a former paper.[2]

The zones on the positive knob in which the luminous drainage streamers take their origin are shown in Fig. A, Plate II. The camera exposure and development were so adjusted that the streamers themselves shown in Fig. B, Plate I, did not develop on the plate. No flashlight was made in this exposure. The same exposure, followed by a flashlight is shown in Fig. B, Plate II. It will be observed that the central point of the knob-face, nearest to the copper sheet, is in these two figures, a non-luminous area.[3]

Figures C and D, Plate II, show two photographs of the positive knob, taken through a small hole in the copper plate. The knobs and the brass rods on which they were mounted were laterally displaced, in order to make room for the camera. The length of the spark-gap at *a*, appears to determine the number and arrangement of these luminous zones from which the streamers spring. In Figs. C and D, the exposure was somewhat increased, and traces of diverging streamers are shown.

It seems evident that these dark spaces lying between the luminous cones springing from these luminous zones, are in the nature of Faraday dark spaces. They are tubes of discharge within which supercharged molecules of air from the copper plate, mingled with molecules having a normal charge, move towards the positive knob.

When the conditions exist which are shown in Fig. C, Plate I, they actually deliver their charge to the knob itself. When the drainage streamers have formed, these super-charged molecules pass into them. Their charge then continues by conduction to the positive knob, while they move back in an opposite direction towards the copper plate, along the luminous streamers. That a sim-

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[2] These Trans. XIX, No. 4, pp. 67–8.

[3] In Fig. B a reflection of the flash from the polished surface of the knob is seen, as well as a sharply defined image of a wire screen back of the flash.

ilar structure may sometimes exist within the negative glow, is shown in Figs. A and B, Plate I.

It appears probable that the oscillations which are set up in the small gaps *a* and *a′* result in bringing about a surging to and fro of the electric fluid within the metal conductors leading to the spark-knobs. The oscillations in a disruptive discharge are simultaneous in time, but are distributed along the line of the discharge. They are space alternations of dark and luminous columns, in which the air is for the moment surging in opposite directions, as in an organ pipe sounding a high harmonic. In the vacuum tube they are called striae. These space alternations which might be called sound waves may be superposed on each of the successive time alternations which may occur in a disruptive discharge. The successive time alternations depend on resistance, self-induction and capacity. The space alternations which are simultaneous in time, are electrically produced sound waves.

It is now evident that the surging effects set up in the lines leading to the main spark gap, account for the difference between the two discharges shown in Figs. B and C of Plate XXV, in No. IV of Vol. XIX of these Transactions. A small gap in the negative approach line at *a′* of Fig. 2, p. 64. (Fig. 1 of this paper) causes the discharge from the negative terminal to become more widely divergent. It is a dark discharge, and is not visible to the eye or in the photograph. It surrounds the luminous drainage column, shown in Fig. B.

When this gap at *a′* is closed and a gap is made in the positive line at *a*, these surging effects exist mainly in the positive discharge line. To some extent they react upon the entire system in each case. The discharge then comes from zones of larger radius on the positive knob. The positive streamers are then more widely divergent in co-axial cones. The dark discharge then sweeps through the region of the central axis of the cones which diverge from the positive knob. This accounts for the

behavior of the mica windmill as described in the former paper, p. 67.

Some work has been done in the study of the effect of imposing sound vibrations upon a column of air in a resonance tube, along which an electric discharge is passing. It has been found that the electrical discharge is affected by the system of standing waves. A luminous column has thus been converted into a dark discharge. The musical tones which accompany the surging to and fro of the air molecules in a gap, have been somewhat reinforced by placing the discharge gap within a resonance tube, whose length could be adjusted to the musical note.

The air vibrations which are thus produced are, however, not in harmony with the conditions which must exist in a system of standing waves. A complete wave consists of a dark space and an adjacent luminous column. The air molecules in these semi-waves are being urged in opposite directions. The nodes where at any instant we may suppose conditions of alternate maximum and minimum pressure to exist, along the discharge, lie between the dark and the luminous halves of the waves. At the same time these nodes have been transformed into points of maximum and minimum conduction. These are, however, the conditions which exist midway between nodes. Such electrically produced sound waves will thus have a progressive motion. This progressive motion is maintained by the forced transfer of the negative corpuscles, which is in the same direction in the conduction and in the convection halves of each wave.

The prolonged roar which accompanies a lightning discharge may be brought about by such a system of electrically produced sound waves. A rattling vibration may often be heard in overhead thunder, which strongly suggests ripples superposed on a conduction discharge. Of course reflections from distant cloud-like masses of air, and effects due to varying distances of the discharge channel from the observer are not here referred to.

It is such a system of air waves that has been described as a "series of partial discharges" when the discharge of a Leyden jar is examined by means of a rotating mirror.

THE DRAINAGE COLUMN.

Since the publication of former papers the writer has listened to criticism for the use of the phrase "drainage column." It has been urged that this simply means a column of ionized gas. It seems necessary to say that the use of this phrase is of advantage in explaining phenomena of electric discharge on the one-fluid hypothesis. A mass of air is said to be ionized by X-rays. In such a mass of air, some of the air molecules have lost a portion of their normal charge of negative corpuscles, which have been loaded upon others. These two classes of molecules are mingled together. The average charge per molecule has not been changed. The normal condition soon returns, if the mass of air is left to itself. This is not the condition when a mass of air is under the influence of either terminal of an influence machine. To say that such a mass of air is ionized, is to tell less than the whole story. The corpuscles are drained out of the air in the vicinity of the positive terminal. They are forced out of the negative terminal and into the air in front of it. Of course it is not claimed by anyone that the so-called positive ions issue from within the positive terminal or pass into the negative terminal. The column of air between the terminals is a conductor, but it is a gas, and its molecules are free to move. A transfer of the fluid from molecule to molecule takes place, as it does in a copper wire. The corpuscles leave a molecule which attracts them, and they go to another which attracts them. They are forced out of the negative terminal against its attraction for them and they are drawn into the positive. Cakes of ice would yield under the feet of a runner who should leap from one to another, as air molecules do in an electric discharge, although the ma-

chinery is different in the two cases. Cakes of ice floating on water have as little to do with the athletics of a foot race, as air molecules have to do with the flow of electricity in a power circuit.

The figures of Plate III show clearly the difference between the two terminals of an influence machine. They are camera photographs of a discharge between terminals, having a copper plate midway between them. The Leyden jars have been removed from the machine. The discharge is a brush discharge. Only faint disruptive discharges now and then occur. The copper plate has a hole in it, which in Fig. A is opposite the positive terminal. The negative terminal emits a discharge into the air in front of it. This air is then urged across the dark space to the copper plate. The drainage column from the positive terminal also reaches the copper plate. Air molecules in the hole, in the presence of the negative terminal, also lose their negative charge to the drainage column. The drainage column thus elongates through the hole until it reaches the negative glow. In Fig B, we have precisely the same arrangement, excepting that the hole is in front of the negative terminal. The drainage column does not then reach the hole. Molecules overloaded with negative fluid do reach and pass through the hole, but the copper plate shields the positive knob from the influence of the negative terminal. The negatively electrified particles which pass through the hole induce a small drainage into the positive knob as seen at its lowermost point. This inflow to the knob ceases if the hole is covered with a thin sheet of paper. The other portion of the discharge is unchanged. In Fig. C of Plate III the terminals are in line but the copper plate is displaced. The drainage column which penetrates the hole is partially intercepted by a small disk of copper mounted on a glass support. This copper disk obstructs the drainage column which reappears at its edge.

In Plate IV loud disruptive discharges are similarly treated, the Leyden jars being connected with the terminals. In Figs. A and B the hole in the copper plate is opposite the positive terminal, but in B the hole was covered with a thin sheet of paper which was hung over the upper edge of the plate. Its effect was to obstruct the drainage flow exactly as would have been done if the hole had been filled with copper. Disruptive discharges along this obstructed path are then also prevented. In Fig. C, the hole in the copper plate was opposite the negative knob. The discharge knobs and rods were put more nearly in line than in the former case, in order to give the negative terminal a better opportunity to behave as the positive had done in Fig. A. The discharge was apparently exactly the same as if no hole existed in the plate.

If the knobs are separated somewhat more widely, than in the experiments just described, and the copper plate is placed midway, no sparks will pass to the plate if the drainage column is obstructed by the plate. They pass when it is removed. A continuous plate of sufficient size, or a plate having an opening in it, which is covered with a sheet of paper, will obstruct the drainage column. It reaches the plate, and reappears at its edges and corners. It may curve towards the cathode knob from the edges of the plate. If they are so far from the cathode that this conducting channel does not reach the negative glow, no spark will pass. The effect of displacing the plate in its own plane so as to diminish the distance from one edge of the plate to the negative knob, is shown in Plate V, Fig. A, and in Plate VI, which is an enlarged copy of a similar photograph. The luminous conducting column along which the discharge passed could be distinctly seen just before the spark passed. This glow does not show in the photograph, partly because the development was not continued long enough to bring it out, and partly because the light of the discharge obscures it when this is attempted. It is evident that mole-

cular impact is involved in the progressive elongation of this drainage column, but it is the presence of the drainage or conduction column which brings about the discharge from the cathode knob.

Plate VI, and many others which have been secured show very clearly the spitting off of the discharge into the air at sharp angles in the discharge channel. As was stated in the first paper presented (No. 1 of Vol. XIX), some results of this kind around a sharp angle in a wire were secured. It was then thought that the direction of flow of the discharge might thus be determined. Many plates like this here shown reveal this effect. At the end of the channel nearest to the negative terminal, the spitting off at an angle is such as would be explained by a momentum effect of the negative particles. At points in the channel near to the copper plate, effects are shown which could be explained as a spitting off of a "positive discharge" in passing around the angle in the opposite direction.

In experiments with the angle in the wire, when the plate was enclosed in a hard rubber holder, and placed at the angle it required an exposure to thousands of spark discharges when the angle was in the positive wire, in order to obtain an appreciable effect where three or four or even a single discharge would produce like effects when the angle was in the negative line. In the positive line when the plate was enclosed the effects were always on the side of the angle which indicated that a negative discharge from the ground had produced the effect. In Fig. A, Plate V, of the present paper, these camera photographs of a disruptive spark in air, show near the positive end an elongation of the drainage channel at an angle, in a manner which may be explained as a momentum effect of the air molecules, while they are parting with negative corpuscles, and where the main drainage column is suddenly changing direction. The fogging effect upon a photographic plate placed on one side or the other of an angle in a wire gave results which

seemed of doubtful value after two years of constant work. The character of the difference in results when the plate was enclosed in a case of hard rubber and when it was wholly exposed to the wire in the positive line seemed unexplainable, until the idea finally suggested itself that the positive brush discharge was a negative inflow, or drainage into the exhaust terminal.

These results give a clear explanation of the reason why in forked discharges the ends of the branches or forks point towards the negative terminal.[4]

These branches are drainage channels.

Figs. B and C of Plate V, were made under the same conditions as Fig. A of Plate XXI, in No. 4, Vol. XIX, of these Transactions. They show more clearly how the radial discharge lines from the negative pin head terminal or cathode are crossed by the drainage lines from the grounded pin head. They also show how these lines unite when they meet end on, and how the drainage lines are distorted in the region where the opposing "winds" mingle with each other. Even in air of atmosphere pressure, the drainage lines extend beyond the cathode terminal.

These plates had pin-heads resting upon the photographic film. They formed the terminals of a gap in the grounded negative line from the influence machine. A faint disruptive discharge across a minute gap at the machine, was accompanied by a glow across the plate between the pin-heads. A disruptive spark there was avoided.

The distortion of the drainage lines as they approach the negative glow, shows the effect of the commingling of the super-charged molecules urged outwards from the cathode pin-head, and the molecules of air or metal, from which negative corpuscles have been drained, and which are moving in the opposite direction. When a copper sheet is placed transversely across the middle

[4] See Thomson's Recent Researches in Electricity and Magnetism, p. 169, Fig. 73.

of this gap, the region covered by the distorted drainage lines become a dark space as is shown in former papers. See also Fig. B of Plate I, of the the present paper.

Discharge Through Solid Conductors.

In the former paper, No. IV of Vol. XIX, of these Transactions, reference was made to a form of electrical pumping service, in which a charged sphere is assumed to collapse in such a way as to maintain a constant potential, while current is flowing from it through a resistance R to a sphere of zero potential and infinite capacity. A better example may be cited as follows:

Suppose a copper wire of radius r and length L to be surrounded by a co-axial surface of radius r'. The two surfaces form a condenser of capacity

$$C = \frac{L}{2\, log_{\epsilon} \rho}$$

where $\rho = \frac{r'}{r}$.

Ground the outer shell, thus keeping its potential zero. Charge the wire core to a potential V. Connect one end of this core to a ground of infinite capacity through a resistance

$$R = \frac{l}{ks}.$$

Move the condenser towards the resistance R with a velocity v, and assume that the condenser-wire collapses longitudinally at the point where it makes contact with the resistance R. The velocity v is to be so adjusted that the potential V remains constant. The current delivered to the wire of resistance R is then

$$i = \frac{dQ}{dt} = V\frac{dC}{dt} = \frac{V}{2\, log_{\epsilon} \rho}\,\frac{dL}{dt}$$

The velocity with which the wire must move is

$$v = \frac{dL}{dt} = 2\, log_{\epsilon} \rho\, \frac{i}{V} = 2\, log_{\epsilon} \rho\, \frac{1}{R}.$$

From this equation it would appear that if the capacity of the condenser per unit length is infinite or $\rho = 1$, the velocity v will be zero if $R > 0$.

On the other hand if the velocity v were made equal to that of light, R being in electrostatic units

$$log_{\epsilon}\rho = \frac{1}{2} 3 \times 10^{10} R$$

If R is measured in ohms

$$log_{10}\rho = \frac{0.434294 \times 3 \times 10^{10} \times 10^{9}}{2 \times 9 \times 10^{20}} R$$

$$= 0.007238 R$$

The values of ρ for various values R are given in Table I.

TABLE I

$v = 3 \times 10^{10}$

R	ρ
0.1	1.0016
1.0	1.0168
10.0	1.181
100.0	5.294

TABLE II

$\rho = 1.0016+$

R	v
0.1	3.00×10^{10}
1.0	3.00×10^{9}
10.0	3.00×10^{8}
100.0	3.00×10^{7}

If the value of ρ be made 1.00164+ as in the case given in the first line of Table I, the value of v for the various values of R are given in Table II. The current delivered will of course depend on the value V.

The quantity of electricity per unit length of the condenser core is

$$\frac{dQ}{dL} = \frac{v}{2\, log_{\epsilon}\rho} = \frac{V}{Rv} = \frac{i}{v}$$

The current in terms of the velocity v is therefore

$$i = v \frac{dQ}{dL}$$

If we now consider the conditions within the wire of resistance R, to which this current is being delivered, v'

being the velocity with which the fluid flows in the wire, we shall have an equation similar to the last, or

$$i = v' \frac{dQ}{dl} = \frac{V}{l} ks$$

On the condenser core, the convection current is carried on a thin film of its surface. In the wire of resistance R, the same current is distributed uniformly over a cross-section s. The relation between the conduction resistance R and what may be called the convection resistance is

$$\frac{2 \log_{\epsilon} \rho}{v} = \frac{l}{ks}$$

When the values of v and ρ satisfy this equation the potential of the condenser core will be constant and the current through R will therefore be constant. The velocities v and v′ will then be such as to satisfy the condition.

$$v \frac{dQ}{dL} = v' \frac{dQ}{dl}$$

If the wire of resistance R were now to be replaced by one having a length $2l$ and a section $2s$, the current would remain unchanged. The potential or electrical pressure at the end which joins to the condenser core would remain unchanged. The current per unit cross-section and the drop in potential per unit length will be half as great as before. If we are to consider the amount of moving electric fluid contained in $1cc$ of the wire to be the same as before, then v' will have been reduced to half its former value, and $\frac{dQ}{dl}$ will have been doubled. It would then require four times the time for a given element of the fluid to traverse the resistance R, that was needed for the wire of half the length. This involves an abrupt change in the velocity of the corpuscles, at the point where the cross-section s changes, in any circuit. Assume that a conductor of different material in which k is greater and l correspondingly greater replaces the one first discussed. It seems possible that the molecular structure might be such that v' might be either greater or less than in the conductor which it replaced.

To take a rough illustration, a column of sand and a column of shot having equal cross-sections, might have their lengths so adjusted that they would offer equal resistance to the flow of an air current. The linear velocity of air molecules would be very different in the two columns, if one were to replace the other in the same circuit. A column of cotton fiber might have the same specific resistance as a column of shot, and the linear velocity of the air molecules might be very different when the same current was being forced through them.

It seems possible that abrupt changes in velocity of the corpuscular current in a circuit where unlike metals are involved may be an important element in the thermal behavior of such circuits, at points where unlike metals join.

The sudden change in velocity of corpuscles when they leave the luminous conducting channel of an electric arc and enter the positive carbon, is an illustration of the action here discussed. Such a change would account for the high temperature of the positive carbon.

An iron wire forming part of a circuit the rest of which is copper, and through which a current flows, is heated at one junction and cooled at the other. These effects are exchanged on reversal of the current. The resulting temperature will depend upon specific heats of the two materials, as well as on radiating surface per unit of mass in which the heat is developed. All of the properties involved vary with temperature, and some of them are very imperfectly understood.

It has long been known that when metals are heated they exhibit electrical properties. Through a certain range of temperature a metal will "emit positive electricity," or as we would now say, it will drain negative electricity from the surrounding air. This effect is greatest at a certain temperature, which is different for different metals.

The positive ions which are at the same time urged from the heated metal are molecules of air or other gas or of the metal terminal, which have been drained of their

negative charge. The latter goes to earth through the ground wire. A metal rod, one end of which is at a higher temperature than the other, if surrounded by air would until a condition of equilibrium were reached, tend to acquire a negative charge. If the two ends of such a bar or wire were united by a metallic conductor of different material, having the same properties but in a different degree at the same temperatures, we have the conditions for a thermo couple. The phenomena are under such conditions observable at much lower temperature than is possible when ionization of the air or action through an air space must be utilized for detection of the phenomena.

Each wire serves as a metallic conductor to connect the terminals of the other. Each wire readily drains from the other the fluid which is only imperfectly drained from air. The effect is, however, in general a differential one. The physical properties which determine the values v′ are probably involved.

EXPLANATION OF PLATES.

Plate I. — Fig. A. Camera photograph of brush discharge in open air. Canal ray through hole in copper plate. Oscillations in the negative approach line. Fig. B. Same with oscillations in the positive approach line. Fig. C. Dark discharge. No oscillations. Flash light after the electrical exposures.

Plate II. — Fig. A. Shorter camera exposure. Positive knob as in Plate I, Fig. B. No flash light. Fig. B. Same followed by flash light. Figs. C and D. End view of positive knob terminal.

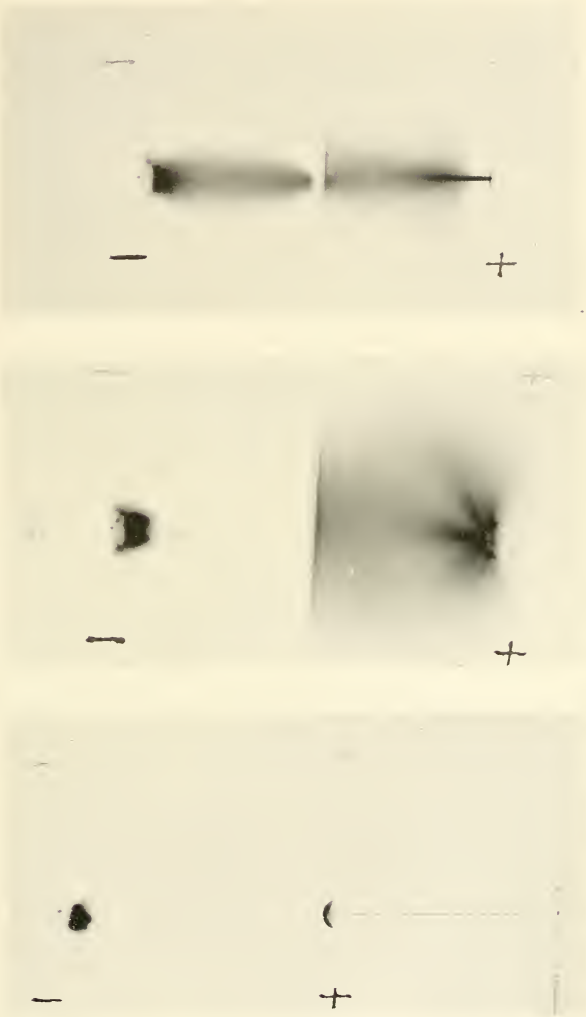
Plate III. — Fig. A. Brush discharge. Canal rays through hole in copper plate. Fig. B. Hole in the copper plate is opposite the negative knob. Fig. C. Hole in the copper plate is displaced. An insulated disk of copper in the canal ray.

Plate IV. — Fig A. Disruptive discharge along canal ray, through hole in the copper plate. Fig. B. Same with a thin sheet of paper hung over the copper plate, cutting off the canal ray. Fig. C. Hole in the copper plate opposite the negative terminal, as in Fig. B, Plate III, but with disruptive discharge.

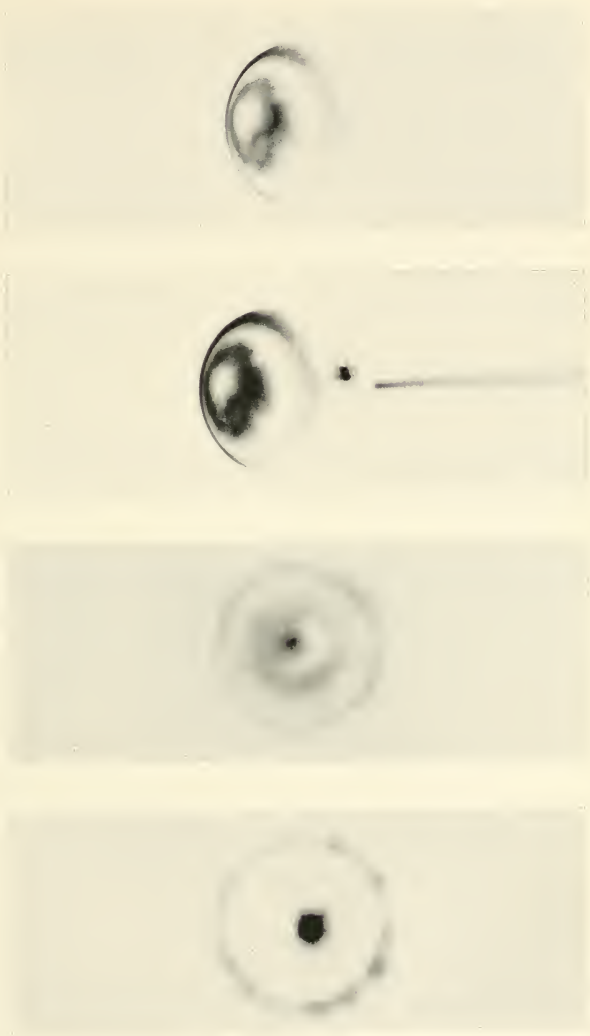
Plate V. — Fig. A. Disruptive discharge to edge of copper plate, momentum effects at the sharp angles in the discharge. Figs. B and C. Glow discharge over photographic film between pin-heads, due to a minute spark near the machine. Crossing of drainage lines from the ground and radial discharge lines from negative pin-head.

Plate VI. — Enlarged copy of a discharge like Fig. A of Plate V.

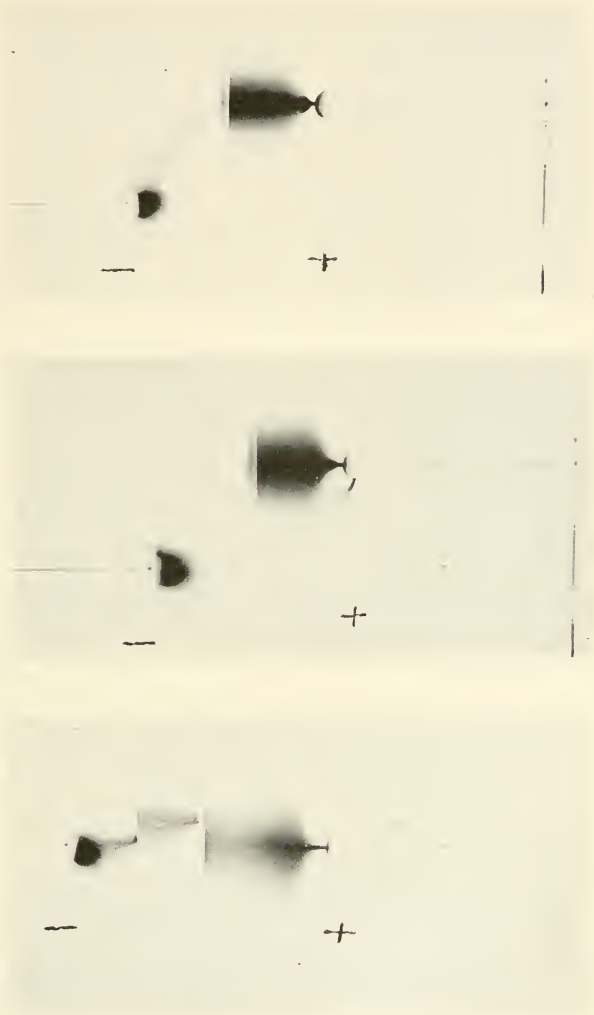
Issued February 28, 1911.



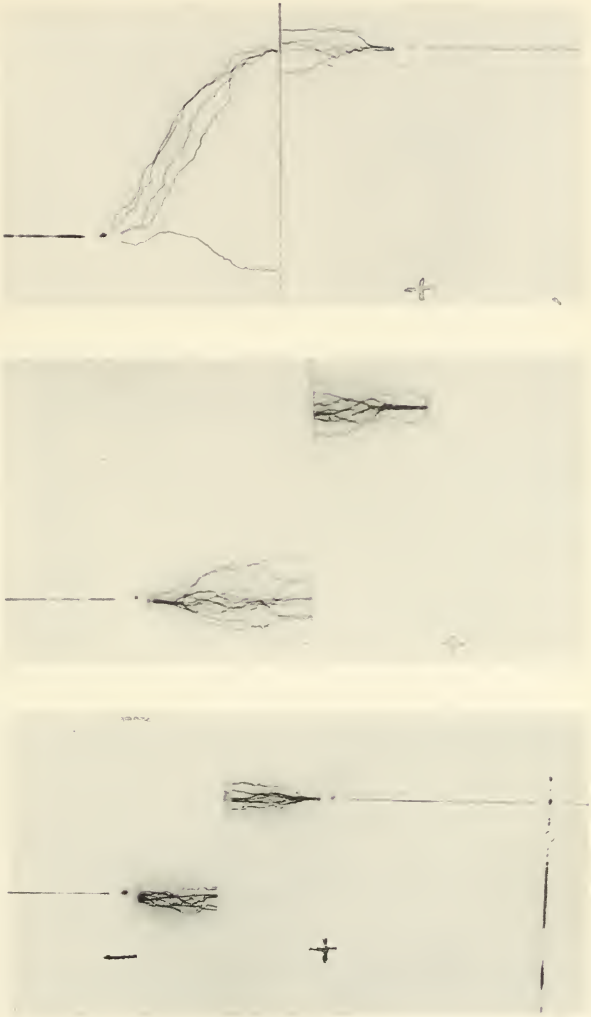
Figs. A., B. and C.



Figs. A., B., C. and D.



Figs. A., B. and C.



Figs. A., B. and C.

Figs. A., B. and C.

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FOUR NEW PLANTS FROM MEXICO.

CHARLES HENRY THOMPSON.

Issued April 21, 1911.

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Continued on page 3 of Cover.

FOUR NEW PLANTS FROM MEXICO.*

CHARLES HENRY THOMPSON.

A YELLOW FLOWERED MORNING-GLORY.

In the fall of 1906 the Missouri Botanical Garden received from Mr. Rudolph Holtzwart, of St. Louis, two seeds of a morning-glory, part of a number sent him from Torreon, Mexico. In the latter part of August, 1910, the writer had opportunity to see the plant from which these seeds were taken. It was growing as a cultivated plant and trained up over a two-story house and over a tall tree. Near its base the stem was about 8 cm. in diameter, freely branching above, some of the branches reaching a length of several hundred meters. The Garden succeeded in growing one plant from the seed received, and this flowered abundantly in its second season of growth. The first year the vine attained a length of about 4 m. and formed a tuber-like root-crown about 3 cm. in diameter in the middle, and 15 cm. long, subtended by a number of fleshy roots, the size of a lead pencil, and smaller. The stem was frozen to the ground after which the root was transplanted in the greenhouse, in open soil, where it remained till January, 1909.

As the plant flowered and fruited it was carefully compared with extensive herbarium material, as well as descriptions of all the species of *Ipomoea* published, in an unsuccessful attempt to identify it. Careful study has been made with reference to Professor House's especially good monograph[1] of the genus. A comparison of our plant with the different genera, as recognized by Professor House, which have previously been assembled

* Presented by title before The Academy of Science of St. Louis, February 20, 1911.

[1] House, H. D. Annals N. Y. Acad. Sci. **18**: 181-263, 11 May, 1908.

under the genus *Ipomoea,* shows conclusively that it is a true *Ipomoea.* The large foliage and the inflorescence somewhat suggests the genus *Operculina,* but the absence of even the slightest tendency of the anthers to become twisted after dehiscence and the loculicidal dehiscence of the capule definitely exclude it from that genus. As an *Ipomoea,* the plant falls in the section Batatas and subsection Aequisepalae of the above cited monograph. A like comparison with the number of species thereunder described shows it to be one not therein described. To remove any possible doubt on this point complete herbarium material and notes were submitted to Professor House, who replied that he did not recognize the plant as identical with any North American species known to him. Later I had the pleasure of going over my notes and the material in the Missouri Botanical Garden herbarium with Dr. Hallier, of Berlin, and he identified this species, not as one of *Ipomoea,* as he recognizes the genus, but of *Merremia.* *Merremia* is characterized by five strong dark lines or veins running parallel through the five longitudinal bands of the corolla—representing the midveins of the cohering petals. Furthermore, the anthers of *Merremia,* after dehiscing, twist spirally around on their longitudinal axes. The latter character is entirely absent in our specimen and the former can scarcely be recognized. It seems, therefore, in my judgment, certainly to belong to the genus *Ipomoea* as recognized by Professor House.

The following description was drawn from the living plant as it appeared in the latter part of October and early November, 1908.

Ipomoea grandidentata n. sp.

Stout perennial twining plant. Stem 15 m. long, from several long very fleshy roots. Main stem light brown, roughened by raised lenticels, 1.3 cm. in diameter, ligneous, freely branching; branches green, tinted with purple where exposed to the sun, early roughed by the raised lenticels, otherwise glabrous; whole plant glabrous throughout; internodes 10-15 cm. long. Leaves cordate-ovate in outline, base rather

deeply cordate, apex acuminate, margin subentire (very slightly undulate) to (more commonly, especially in the earlier season of growth) coarsely dentate; the basal dentations rounded, the lateral ones acute; petiole 5-17 cm. long, 1.5-3 mm. in diameter, blade 7-18 cm. broad by 10-20 cm. long. Inflorescence cymose, 1-10 buds maturing to flower, usually the peduncle one-flowered by the falling away of the rest of the inflorescence or else developing into two branches, each branch a one-sided raceme; peduncles 7-20 cm. long, pedicels 1-1.5 cm. long, trumpet-form, 7 mm. in diameter at the base of the sepals, tapering to 2.5 mm. at the base. While open the flower hangs horizontally, after which the pedicel curves so as to bring the fruit upright. Sepals coriaceous, ovate, slightly unequal, about 1.5 cm. wide, 2.5 cm. long (enlarging with the development of the fruit), apex obtusely rounded with a very minute grooved mucron, closely imbricated in the bud, during the flowering period and after the fall of the corolla; pedicels and calyx covered with a waxy resinous coat as are also the very young branches and leaves. Corolla bright chrome yellow throughout, tube twice the calyx length, narrowly funnel-form, quickly expanding into a wide spreading limb; tube about 1 cm. in diameter where it emerges from the calyx, limb 6-7 cm. in diameter, irregularly crenate and finely crenate-dentate. Stamens inserted in a ring on the corolla tube, about 5 mm. from its base; filaments of different lengths, 5-12 mm. long, tapering from a broad dorsally flattened base upward to the anther, the broad bases curved inward and upward so as to close the corolla tube above the nectaries, leaving only a very small round opening between their bases, next the tube wall, sufficiently large to allow the entrance of a nectar gathering insect's beak; filaments sparingly glandular, pubescent in the lower two-thirds, pale yellow; a minute funnel-form pit behind each filament at its juncture with the tube wall; anthers white, long oblong, 6 mm., deeply cordate at the base, in no wise spirally twisted; dehiscence longitudinal. Annulus raised, rounded 5-angled and with a rounded lobe at each angle. Pistil 2 cm. long, ovary 2-celled, 2 ovules in each cell; style tapering to the two-lobed capitate stigma. In maturing the sepals grow to a great size, always closely imbricated, forming an ovoid body with a quite long tapering point, which is formed by the tight rolling together of the sepal tips. When ripe these sepals become dry and stand out in a rotate 5-pointed star at right angles to the ovary or shallowly cupulate. They are then lance-ovate in outline, concave within, convex without, and the margins variously undulated and variously inrolled or revolute toward the apex; only slightly unequal, 2-2.3 cm. wide by 3.4-4.6 cm. long. Fruit ovoid, laterally somewhat compressed, 2.1 cm. long, greater diameter 2.3 cm., lesser diameter 1.8 cm.; wall thin, parchment-like but brittle; dehiscence loculicidal. Seeds about 8.2 mm. thick, 12 mm. and 13 mm. long, brown-black, half-ovoid, the flat inner face sloping off obliquely at the lower end. In the central portion of this sloping base is located the large circular hilum, 3 mm. in diameter, surrounded by a comparatively broad ring, 6 mm. in

diameter. The two angles formed by the juncture of the convex and flat surfaces of the seed are outlined by a narrow line of dense, short, glossy black hairs on one and two such lines on the other angle; on the lower lateral sides of the concave surface are small rather closely set patches of like hairs. The reason for the presence of two lines of hairs on one angle and one on the other may be explained by the fact. that had all four ovules developed then each seed would have had the shape of a longitudinal one-fourth section of an ovoid—i. e., with two flat faces and one convex one, and on each of the three angles would be a line of these short hairs. Since in our specimens there was but one seed in each cell, these each occupied the entire space of the cell and took on a half-ovoid shape, bringing two angle-lines of hairs close together.—Plate VII.

The original plant (No. 232/07/1) is growing at the Missouri Botanical Garden as are also several cutting propagations from it. Herbarium material was made from the original plant and specimens deposited in the herbaria of the Missouri Botanical Garden and of Professor H. D. House, Biltmore, N. C.

Three New Crassulaceae.

The Missouri Botanical Garden now possesses a very good living representation of the Crassulaceae. Many of the specimens have been derived directly from the Mexican field, and, since the appearance of the monograph of the order, by Britton and Rose,[2] it is quite evident some of these species are nondescripts. In presenting the following species the classification and form of description used in the above cited monograph have been followed as nearly as possible.

Echeveria fimbriata n. sp.

Caulescent, stem 4.5 dm. to the rosette, 2 cm. in diameter. Rosette open, comparatively few leaves; leaves oblanceolate, 12 cm. long, 6.2 cm. wide,—3.5 cm. from the rounded obtuse apex, tapering to a very thick base. 2 cm. wide by 1 cm. thick, valiculate concave in the expanded blade portion, groove-channeled down the upper face of the basal portion, where the margin is thin, narrow, and sharp wing-like, and the under surface convex with a prominent obtuse keel, which ends in a decurrent obtuse spur below the transversely oblong attachment.

[2] Britton, N. L. and Rose, J. N. N. A. Flora **22**: 7–80, 22 May, 1905.

Smaller young leaves decidedly purple, tinted on both surfaces, except a thin, hyaline, finely fimbriated margin; older larger (as described above), of light green color and no purple tint, with a thin narrow, nearly transparent, fimbriated margin. Neither leaves nor stem show any indication of glaucousness.

Flowering stalk arising from below the rosette, obliquely ascending, rather scattered leafy throughout, the lower portion of the same pale green as the main stem, but the upper portion tinted with brownish-red and only in the inflorescence becoming glaucous; lower bracts differing from the mature leaves of the rosette in size, 5.5 cm. long by 2.5 cm. broad, and in being finely denticulate instead of fimbriate. These bract-leaves become smaller toward the inflorescence where they are only 1.8 cm. long and lanceolate in outline, somewhat purple-tinted and glaucous. Inflorescence of two secund racemes; lower pedicels 1.5 cm. long, curved by the weight of the flower, neither articulate nor bracted; calyx lobes decidedly unequal, lanceolate, and, like the pedicels, pale green slightly tinted with purple and quite glaucous, nearly horizontally spreading. Corolla 5-angled, 1.5 cm. long, 1 cm. in diameter at the base, slightly tapering to the recurved obliquely spreading tips; petals separate to the base, lanceolate, gradually tapering from the middle to a long acute apex, somewhat gibbous at the base and obtusely angled on the back, outer surface rose pink, strongly glaucous, tips recurved so the apex points at right angle from the axis of the flower, inner surface light orange yellow, tinted with red at the very apex and part way down the median line by short, straight, longitudinal, red pencilings; gland large, lunate. Stamens inserted alternately in two planes, tapering from the base upward, pale yellow, anthers of the same color. Ovary white, three-fifths the pistil length; style dark red-purple, tapering upward to the green stigma which is somewhat recurved at maturity; anthers and stigmas in one plane.—Plates VIII-IX.

The plant, collected by Dr. Trelease at El Parque, Morelos, Mexico, in 1905 (M. B. G. No. 102/05/3), appears to be quite distinct from anything heretofore described. The individual flowers are nearly identical with those of *Echev. Scheerii,* Lindl. but the plant is quite different in all vegetative characters. It differs from all other species in having fimbriated leaf-margins—a character not to be observed in any other species save to a slight degree in quite young leaves of *Echev. fulgens,* Lem.

Sedastrum pachucense n. sp.

Perennial. Stems numerous, from a root crown, erect, spreading or declined, simply or paniculately branched above, 3-4 mm. in diameter,

12-18 cm. long, grayish-green, penciled with numerous small, short, longitudinal, purple lines, glabrous throughout; stem leaves linear oblong, cylindric or somewhat dorsally compressed, standing at right angle to the stem or the apical, ½-½ slightly recurved, slightly tapering to the thick base, apex rounded-obtuse, glabrous and glossy light green, very tenderly succulent, 4.5 mm. wide, 3.5 mm. thick, 1.5-2 cm. long, gradually reduced in the branches to oblong or obovoid; rosettes formed at the base of or on the lower part of the stem, depressed globose, 1.8-3.5 cm. in diameter, dense, of many leaves; leaves very succulent, long oblanceolate to spatulate and biconvex or dorsally-compressed clavate, 3 mm. wide at widest portion, one-half as thick and 1 cm. or less in length, bright light green, finely dotted with purple, gray puberulent in the apical half, especially about the margins of the obtuse apex, glabrous and shining below; flowers solitary in the axils of the bracts on the ultimate branches of the stems, sessile; sepals obliquely spreading, very unequal, succulent, short lanceolate, apex bluntly acute, green like the foliage and bracts, slightly puberulent; corolla 8 mm. in diameter, rotately spreading with the tips of the petals slightly recurved, petals white with a short green median line on the dorsal side toward the apex, free, lance-ovate, acute; stamens 10, those opposite the petals adhering to their bases for ½-½ the petal length, those alternate free to the base, all as long as the petals and strongly reflexed, filaments white, anthers pale greenish-yellow; the gland a comparatively large yellowish callous with greenish margin; carpels at first erect, gradually becoming recurved and divergent with development; ovary papillose, finely dotted with purple, tipped with a slender style.—Plate X.

Collected by C. H. Thompson, August, 1910, at Pachuca, Hidalgo, Mexico, where it grows among rocks and low shrubs on the mountain sides above the town. (M. B. G. No. 260/10/72.)

This species has much the habit of *Sedastrum Hemsleyanum* (Plate XI) and on superficial examination would readily be mistaken for that species but may be readily distinguished by the characteristic forms of both its cauline and rosette leaves. The flowers are identical in form but somewhat smaller in the above described species. It seems to approach more nearly to *Sedastrum Painteri,* as described in the monograph, but differs from that species in having neither the flat rosette leaves nor the "broad half-clasping base" of the cauline leaves.

The above description is made from plants flowering in the Missouri Botanical Garden in the winter of 1910-11.

Sedum versadense n. sp.

Perennial, much branched from the base, branches at first short and with the closely set leaves forming rosettes, later elongating and reaching 2 dm., decumbent with ascending tips, rooting at the nodes, pubescent, leafy. Leaves alternate, sessile, obovate-cuneate to obcordate-cuneate, 9-18 mm. wide, 1.3-2.5 cm. long, fleshy, thick, flattened, apex usually deflexed, rounded margins slightly upturned, pubescent, light green, frequently red margined at the apex or the red also extending downward on the under surface beneath the apex. Flower stalks upright, terminating the branches, 3-5 cm. long, leafy-bracteate; these from triangular-obovate with obtuse apex to broadly lanceolate with acute apex, grading into the bracts of the inflorescence, glabrous and slightly glaucous. Inflorescence divided into two or three secund racemes, leafy-bracteate; bracts broadly lanceolate, fleshy, 2-3 mm. wide, 4-6 mm. long, glabrous, slightly glaucous; pedicels about 3 mm. long; sepals distinct, lanceolate, very unequal, little shorter than the petals, fleshy, convex on both surfaces, sharply acute; spreading nearly horizontally in flower, nearly erect in fruit, slightly incurved, scarcely distinguishable from the bracts; flower buds purplish-pink, petals spreading, later becoming recurved, lanceolate, mucronate, 2 mm. wide, 5-6 mm. long, light purplish-pink to almost white, keeled on the back, channeled down the face; stamens obliquely to horizontally spreading, one-half the petal length, those opposite the petals inserted a little above the base, those alternate inserted at the base, filaments white, anthers ovoid, abruptly acute, bright rose-red; carpels distinct, erect, styles tapering to the stigma, slightly spreading in flower, erect in fruit.—Plate XII.

Collected by Dr. William Trelease, February, 1905, at Versada, half way between El Parian and Tomellin, Oaxaca, Mexico. (M. B. G. No. 47/05.)

A study of the plant in connection with Britton and Rose's recent monograph of the American representatives of this order would throw some doubt on its generic position. The rosette arrangement of the pubescent leaves and the erect carpels very strongly suggest affinity with the genus *Sedastrum*, but the ultimate elongation of the rosette into a leafy stem and the production of the inflorescence from its apex are characters not thus far met with in that genus. The form of the inflorescence would place it equally well in either *Sedastrum* or *Sedum*. As between these genera there is a discrepancy in the above cited monograph. In the generic characters given for *Sedastrum* the inflorescence is described as "more or

less paniculate and leafy; the branches arising from the axils of leaves, bearing scattered sessile flowers." In *Sedastrum Hemsleyanum* the inflorescence is described as an "elongated panicle." But the key to the genera places both under the division—"flowers terminal, arranged in one-sided racemes or cymes." Farther down in the key *Sedastrum* is placed in a division,—"Flowers never arranged in panicles." The inflorescence of *Sedastrum Hemsleyanum* Rose, and of *Sedastrum ebracteatum* (M. & S.) Rose, is, in fact, paniculate, but the ultimate branches are secund spikes—not "scattered." The "sessile" character given for the flower might exclude our species from the genus *Sedastrum* were it not for the fact that one species, *S. ebracteatum* (M. & S.) Rose is described as having flowers "sessile or short-pedicelled," a character also attributed to some species of *Sedum*. In the key to the genera the *Sedastrum* group is separated from the *Sedum* group by the former having "carpels erect," the latter having "carpels usually spreading." But for the fact that many species of *Sedum* have erect carpels our plant might fall with *Sedastrum*. A comparison of the characters given for the two genera in the above cited monograph would indicate there is no one distinct character separating them. The "basal rosettes of leaves" ascribed to *Sedastrum* are found in *Sedum* as well, and "the stem * * * dying down to the base after flowering" is not borne out by *Sedastrum Hemsleyanum* Rose, in which the lower portion commonly remains healthy and produces rosettes in the leaf axils which may or may not produce roots, depending on whether or not the stem is recumbent, but ultimately produce branches. But this character is to be observed in *Sedum* as well. Consideration of the floral characters shows no distinction between the genera. The "inflorescence more or less paniculate and leafy," while not agreeing with a large per cent of the species of *Sedum* can, nevertheless, scarcely be considered a distinct character, since many recognized species of *Sedum*

have the flowers in panicles, the ultimate branches being more or less evident secund spikes or secund racemes—in this latter case the flowers very short pedicelled. The individual flowers, in all their parts, show characters common to both genera. "Carpels erect" as attributed to *Sedastrum* is true in the freshly opened flower (the styles are usually slightly curved outward) but as the carpels mature they become quite strongly divergent (with incurved styles), as much so as in many species of *Sedum.* In view of the above observations it seems inadvisable to separate the species under *Sedastrum* from the genus *Sedum.* The great range of variation between the species of *Sedum* as it is now recognized requires that the generic characters be quite elastic,—quite more than sufficient to include the species of *Sedastrum.* With this conclusion the generic position of our plant is quite clear.

EXPLANATION OF ILLUSTRATIONS.

PLATE VII.—*Ipomoea grandidentata.* Inflorescence and characteristic leaf, natural size.

PLATE VIII.—*Echeveria fimbriata.* Rosette of foliage, natural size.

PLATE IX.—*Echeveria fimbriata.* Inflorescence, natural size.

PLATE X.—*Sedastrum pachucense.* Flowering plant, natural size.

PLATE XI.—*Sedastrum Hemseleyanum,* Rose. Flowering plant, natural size.

PLATE XII.—*Sedum versadense.* Flowering plant, x⅔.

Issued April 21, 1911.

IPOMOEA GRANDIDENTATA.

ECHEVERIA FIMBRIATA.

ECHEVERIA FIMBRIATA.

SEDASTRUM PACHUCENSE.

SEDASTRUM HEMSLEYANUM.

SEDUM VERSADENSE.

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STUDIES IN GLACIAL GEOLOGY IN SAINT LOUIS AND VICINITY.

J. ANDREW DRUSHEL.

Issued April 22, 1911.

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Continued on page 3 of Cover.

STUDIES IN GLACIAL GEOLOGY IN SAINT LOUIS AND VICINITY.*

J. Andrew Drushel.

In the Journal of Geology, October, 1908, the writer of this note gave a resumé of the work done on the drift beneath the St. Louis loess up to 1908. Later N. M. Fenneman[1] described drift two miles north of the pumping station at the Chain of Rocks. The section is said to show the presence of two drift sheets with a layer of stratified clay between. The lower is said to be Kansan, and the upper, Illinoian.

During the past two years the writer has re-examined the sections described in his former paper and has found a number of new sections ranging from the exposures north of the Chain of Rocks to South St. Louis, a distance of fifteen miles.

It is the purpose of this paper to describe several new sections typical of the numerous exposures which may be found in this region, to show the glacial origin of the Chain of Rocks bluffs, and to suggest the possibility of three ice sheets in St. Louis and St. Louis County.

On the north and west faces of Kemp's quarry, near Minnesota avenue and Delor street, one block east of the Bellefontaine car sheds, South St. Louis, may be seen an exposure of drift six to eight feet thick, lying on top of the clean-swept St. Louis limestone and beneath loess fifteen to twenty feet thick. (See Fig. 1.) The line of contact between the loess and the drift is remarkably sharp, which is opposed to the idea that the jointed bowlder clay gradually passes into loess. This contact is so

* Presented before The Academy of Science of St. Louis, March 20, 1911.

[1] N. M. Fenneman. Bull. Ill. Geol. Surv. 12 : 8-9. 1909.

sharp that, if the hand be laid on it, the lower portion will touch the drift and the upper part will touch loess. (See Fig. 2.) The bowlders are larger than those usually found in the St. Louis drift and consist for the most part of sandstone, which may be traced to the Coal Measure sandstone in St. Louis County. However, several pieces of igneous material were taken from this section, one of these being polished and striated. This locality marks farthest south for drift of considerable thickness in St. Louis, longitude 90° 14' W., latitude 38° 34' N., approximately.

While excavations were being made for a foundation for the Harris Teachers College greenhouses, Carr Lane, south of Park avenue, 1908, a layer of bowlder clay three feet thick was encountered, lying on the St. Louis limestone. The largest bowlder is a sandstone, well planed and striated. Among the erratics taken from this section are quartzite, sandstone, vein quartz, quartzite, Sioux or Barraboo, probably the former, basalt, greenstone, granite, and several undetermined igneous pebbles. This section was originally covered with loess twenty feet thick. The elevation is 520 feet.

During the construction of the piers for the viaduct on Kingshighway, south of Swan avenue, a section of drift was exposed. Beginning at the base the section shows the following characteristics. Lying on the reddish brown shale of the Coal Measures is a layer of blue bowlder clay about ten feet thick. Overlying this is a layer of pebbly yellowish brown clay, about four feet thick, in which are found granite, greenstone and Sioux quartzite pebbles. A quartz geode weighing fifteen pounds was removed from this layer. Overlying this pebbly layer is a reddish yellow, waxy material eight feet thick. Above this is the loess four feet to six feet thick. This section confirms the blue glacial clay reported by Wheeler,[2] from West Pine boulevard and Tay-

[2] H. A. Wheeler, Trans. Acad. of Sci. St. Louis 7 : 121-122. 1895.

lor avenue, and the "waxy red clay" described by Todd,[3] as occurring on Laclede, near Sarah street.

A short distance southwest of the section just described and northwest of the Shaw School, at an elevation of 560 feet, may be found a region of pebbly material beneath the loess. An area of a block of the latter having been removed by the Laclede-Christy Clay Company, an excellent study of the pebbly material is afforded. On account of the presence of granite pebbles and other igneous material this deposit should be regarded as drift. The gullies heading in this region often show igneous material, which doubtless was derived from the sheet above described.

It is proper to remark at this point that a careful search in the pebbly clay below the loess, which has sometimes been considered a portion of the loess, will, in most cases, reveal igneous material. On this account, and because of the nature of the clay itself, and because the contact in some places between loess and pebbly clay is sharply drawn, this clayey formation should probably be considered a true bowlder clay. For contact see Fig. 2.

In the Chain of Rocks region is a deposit which differs much from the drift described heretofore. The deposit is characterized by great thickness; by the presence of much sand, and of numerous igneous bowlders and pebbles, a cubic foot of material showing 100 pebbles and bowlders of a length greater than one centimeter and less than thirty centimeters, half of this material being igneous; and by the small amount of the stiff bowlder clay. This is a continuous deposit, as shown by the numerous gullies, from Coal Bank road, on the north, to Gibson road, on the south, a distance of two miles or more. A few rods north of Gibson road, in a small ravine drift may be seen lying on Coal Measure shale at a few feet elevation above the Columbia Bottom road. The erratics are unusually large for this region. Several, one

[3] J. E. Todd. Missouri Geol. Surv. **10** : 162-163. 1896.

of which is a basalt, may be seen sixty centimeters to seventy centimeters in longest diameter. This ravine also affords an east and west section across the south end of Chain of Rocks bluffs.

Near the south end of the settling basins of the Chain of Rocks water works a road leads diagonally up the bluff. Drift exposures may be seen from the base of the bluff until within twenty feet of the top, the last twenty feet being loess. A deeply cut ravine on the west side of the bluff heads near this section, the divide at this place being about twenty rods wide. The west side of the bluff consists of drift, as determined by sections in the ravine from the head to the lower end. This drift in general resembles that on the east side, except that the larger bowlders are missing.

The best exposure on the river side of the bluff may be seen where the municipal railway turns away from the Columbia Bottom road (Fig. 6). This section is several hundred yards long and shows glacial material thirty to fifty feet thick, covered by the usual loess deposit. Incidentally it may be remarked that this section affords a fine example of slipping, making the loess appear to lie between two drift deposits. There is marked evidence of stratification, differing from the patches of drift found elsewhere in St. Louis. This stratification appears to be characteristic of the Chain of Rocks material. The significance will be pointed out later in this paper. The section just referred to is marked for its abundance of erratics, such as granite, varying from a very close to a very coarse texture, and from a very light to a very dark color, basalt, greenstone, amygdaloids, rhyolite, quartzite, sandstone, ferruginous chert and quartz geodes. A cubic foot, selected at random, from above the middle of the deposit, furnished 102 pebbles and bowlders, varying from one centimeter to thirty centimeters in diameter, as follows: granite 19, basalt 13, greenstone 10, other igneous 10, quartzite 17, sandstone 5, quartz 8, chert 20;

total 102. Of this number twenty-one are longer than ten centimeters, and fifty-two are igneous. A granite bowlder weighing ninety-five pounds was obtained from this section. (See Fig. 5.) Igneous bowlders of ten to fifteen pounds in weight, lying near the top of the deposit are rather common. These bowlders show the characteristic glacial planing, polishing, and occasional striation. (See Fig. 4.) Now and then a planed granite bowlder is weathered so much as to enable one to shatter it with a light tap of the hammer. (See Fig. 4.) However, as a rule, the pebbles and bowlders appear quite fresh, as compared with drift elsewhere in St. Louis. (See Figs. 3, 4, 5, 8 and 9.)

The deposit just described is, as a whole, much less weathered and more sandy than the other St. Louis drift and the drift north of the Chain of Rocks. This long ridge should probably be interpreted as an outwash of the Illinoian lobe when it occupied the Mississippi flood plain in this region. Such an interpretation would account for the general contour, for the slight stratification and for the grading of the material from coarse pebbles to sand with small pebbles in an east to west section of the deposit, as determined by the gullies on both sides of the bluff.

Leverett,[4] not admitting the existence of Illinoian drift in St. Louis County, has suggested the possibility of an encroachment in the vicinity of St. Louis by the Illinoian ice sheet. "Possibly the Mississippi Valley was encroached upon for a few miles in the vicinity of St. Louis, Mo. There appears to have been at most only a partial blockade near St. Louis. An examination into the character of the deposits in the Mississippi Valley, between Fort Madison and St. Louis, has brought to light nothing to indicate vigorous drainage at the Illinoian stage of glaciation. Indeed, the valley seems to have be-

[4] F. Leverett. U. S. Geol. Surv. Monograph 38 : 64, 71. 1899. The Illinois Glacial Lobe.

come filled to some extent by sand and finer material at places where previous to this glaciation, erosion had been in progress."

This is exactly what one would expect if an ice sheet had occupied the valley for several miles near the Chain of Rocks for a brief period. It seems impossible to account otherwise for granite bowlders lying in the bluff seventy feet above the present flood plain.

On account of its possible relation to the drift in St. Louis, not in the Chain of Rocks region, it appears to the writer that the drift, mentioned by Fenneman,[5] as occurring two miles north of the pumping station at the Chain of Rocks, merits a fuller description than has hitherto been given.

The stream bed above the bridge lies in drift. (See Fig. 10.) In the bed above and below the bridge may be seen bowlders of Sioux quartzite, weighing approximately 200 pounds each. The igneous material among these bowlders is scarce, probably owing to its advanced decomposition. In the sections exposed by the stream there are igneous pebbles, but generally in the lower deposit they are too much weathered to stand removal without shattering. It appears that the granites are more weathered than the basalts.

The section exposed near the bridge by the main stream and a tributary entering at right angles gives a clue as to the nature of the ridge on the left facing up stream. At the top one finds soil and loess, overlying a light yellowish brown bowlder clay, which lies on top of stratified clay almost compact enough to be called shale. Below the latter is a reddish brown drift, eight to ten feet thick. Up stream a short distance one may find the bed of the creek in this deposit. (See Fig. 10.) The bowlders taken from this lowest deposit are chiefly Sioux quartzite, and close textured sandstone. The crystallines are thoroughly weathered. In some cases

[5] N. M. Fenneman. Illinois Geol. Surv. Bull. 12 : 9. 1909.

it is not possible to remove the bowlder from its bed without crumbling. The material, as a whole, is redder than that south of the Chain of Rocks. On account of this advanced state of decomposition and on account of the presence of Sioux quartzite, it is probable that this material is a remnant of the Kansan or pre-Kansan ice sheet. The Cheltenham region in St. Louis, elevation 600 feet, affords material resembling this section.

Just above this lower drift (Fig. 11A) is a bed of interglacial clay (Fig. 11C), almost a shale, five feet thick. The structure is columnar and jointed, the texture is compact and close, the color is cherry brown. The coarsest particles vary from three-fourths millimeters to two millimeters in longest diameter. Many grains are water rounded and are chiefly quartz; vein quartz, rose quartz, agate, and chert are the predominating varieties. The amount of coarse material in this clay is very small, as shown by the following analysis. Two portions of the clay, A and B, each weighing fifty grams when well dried, were washed through a wire sieve of three-fourths millimeter mesh, with the following results. Portion A contained 142 pieces, weighing 160 milligrams, average weight being 1 9-71 milligrams. Portion B contained 212 pieces, weighing 257 milligrams, average weight being 1 15-71 milligrams. Three pieces in B measured more than 1½ millimeters and less than 2 millimeters in longest diameter. In A no grain as large as this was found. It is probable that the above mentioned clay was derived from older glacial drift by streams and deposited in rather quiet water, as shown by the great uniformity of size of the quartz grains.

Two portions of the loess, A and B, several feet above the contact with the upper drift sheet, each weighing fifty grams, were treated as described above for the clay analysis. Portion A contained thirty-nine pieces, weighing seventy-three milligrams. The particles were chiefly angular, only one well-rounded water-worn grain being found. The longest diameters varied from three-fourths

millimeter to 3½ millimeters. These particles are for the most part glassy quartz, weathered chert, and iron concretions. Portion B contained fifty-eight pieces, weighing ninety-two milligrams. In this portion there were seven well-rounded water-worn pieces. Otherwise, as regards shape, size, and composition, there was a general agreement with the fragments of portion A.

For purpose of comparison, fifty grams of thoroughly dried St. Louis loess, with the typical columnar structure and open texture were treated in the foregoing manner. Fifty particles, chiefly angular, varying from three-fourths millimeter to 3 millimeters, weighing 82 milligrams, failed to pass through the sieve. Three pieces were completely rounded, as if water-worn. The particles determinable are quartz, weathered chert, iron concretions. One rock crystal, 2½ millimeters long, was obtained which showed scarcely a trace of water action. From this it appears that there is a close agreement between the St. Louis loess and loess overlying the upper drift sheet mentioned in the next paragraph. But the clay of this section differs from the loess in several essential details.

The drift on top of the clay (Fig. 11E), is about ten feet thick. In the section near the bridge a bowlder of feldspar and quartz porphyry, in a fair state of preservation, was found lying at the top of the upper drift, overlaid by loess ten feet thick. The igneous material of this section is much less weathered than that of the lower sheet. The lower deposit also contains more Lafayette material than the upper. In this respect the drift patches in St. Louis agree with the lower deposit, pointing to a similar origin.

On the whole, this is a very interesting section. Three sharply-drawn contacts may be easily seen. The contact between the lower drift and the interglacial clay and that between the latter and the overlying drift are remarkably sharp. In places a ruler, one inch wide, laid horizontally

on the contact, will cover typical material of the two formations. These contacts are equally sharp in a section twenty rods or more up the main stream.

The stratified clay in this section argues the presence of two drift sheets. The material in both these sheets differs from the Chain of Rocks material in that the latter has fluvio-glacial characteristics. The bowlders of the latter are chiefly granite, relatively few of which are thoroughly weathered. In the former the erratics are chiefly Sioux quartzite, the granites always being much weathered. It is probable that the drift below the clay is pre-Kansan, and that above the clay is Kansan, the Illinoian being represented by the outwash in the Chain of Rocks bluffs.

SUMMARY.

1. A thin mantle of Kansan and possibly pre-Kansan drift, at one time covered the St. Louis region.

2. The present patches are to be accounted for on the basis of erosion previous to loess deposition.

3. Drift of considerable thickness reached latitude 38° 34'.

4. The drift two miles north of the Chain of Rocks represents remnants of the Kansan and possibly the pre-Kansan.

5. The Illinoian lobe occupied the Mississippi flood-plain to a great depth near the Chain of Rocks, and probably pushed into St. Louis County.

6. That portion of the Chain of Rocks bluffs which is drift should be regarded as outwash from the Illinoian lobe.

7. Careful search may reveal Kansan drift elsewhere in Missouri south of the Missouri River.

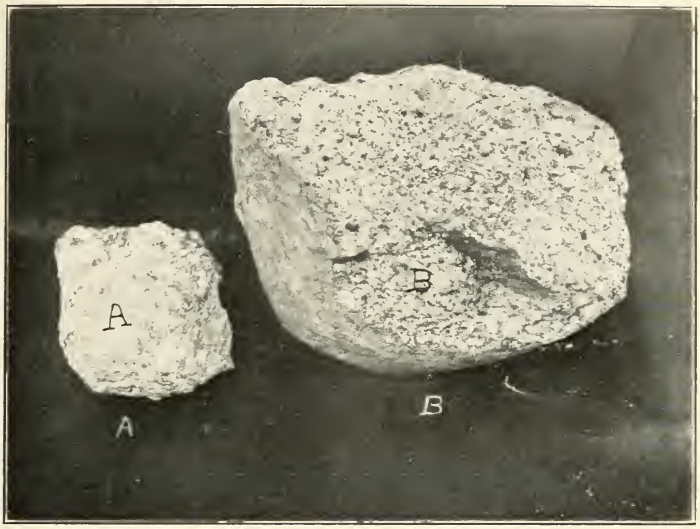

Fig. 3.

Fig. 4.

Fig. 5.

GRANITE BOWLDERS.

Fig. 6.

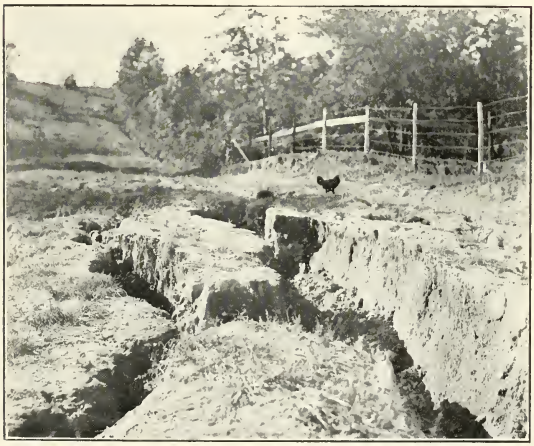

Fig. 7.

CHAIN OF ROCKS DRIFT.

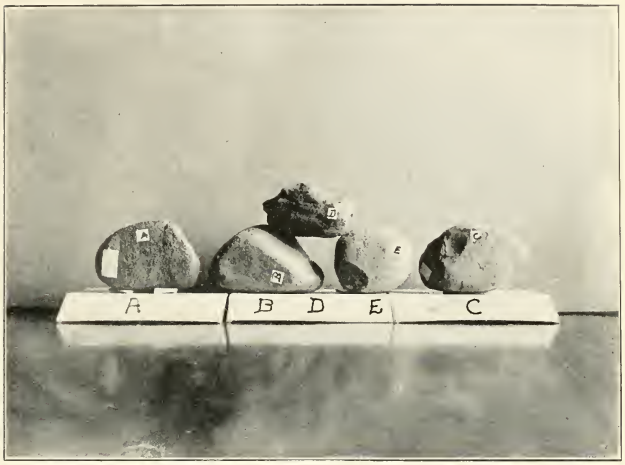

FIG. 9.

FIG. 8.

ERRATICS FROM CHAIN OF ROCKS BLUFFS.

Fig. 10.

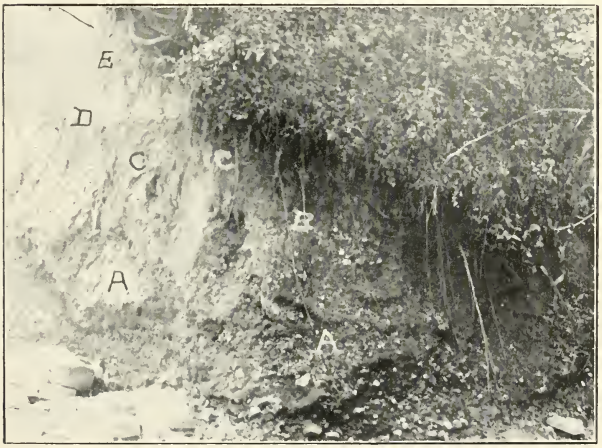

Fig. 11.

DRIFT NORTH OF CHAIN OF ROCKS.

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FIGURATE NUMBERS.

EDMUND A. ENGLER.

Issued June 23, 1911.

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Continued on page 3 of Cover.

FIGURATE NUMBERS.*

EDMUND A. ENGLER.

A consideration of the following properties of natural numbers leads to the sets of series of numbers which have come to be known as *figurate numbers*,[1] and provides a simple method of disclosing some of the properties of these numbers.

If we write a series, each term of which is the number one (1), thus

$$1 \quad 1 \quad 1 \quad 1 \quad 1 \quad . \quad . \quad . \quad . \quad . \quad .,$$

it is evident that the sum of any number of terms of this series is expressed by the formula

$$S = n \tag{1}$$

where n represents the number of terms considered; that is for

$$n = 1, 2, 3, 4, \ldots\ldots, \qquad S = 1, 2, 3, 4, \ldots\ldots,$$

or the nth term of the series 1, 2, 3, 4, ... is equal to the sum of the first n terms of the series 1, 1, 1, 1, ...

Write a number of rows of the number one (1), as follows:

1	1	1	1	1	1	1	.	.	.	.	.
1	1	1	1	1	1	1	.	.	.	.	.
1	1	1	1	1	1	1	.	.	.	.	.
1	1	1	1	1	1	1	.	.	.	.	.
1	1	1	1	1	1	1	.	.	.	.	.
1	1	1	1	1	1	1	.	.	.	.	.

Table 1.

* Presented before The Academy of Science of St. Louis, April 3, 1911.

[1] *Figurate numbers* were so called by Nicomachus (*circa* 100 A. D.) because of the possibility of arranging points in regular figures (plane or solid), according to certain rules, to represent them.

Draw a zigzag diagonal as shown dividing the rectangle of numbers into two triangles of numbers. Divide the left-hand triangle of numbers into rows; divide the right-hand triangle of numbers into columns. It will be evident by inspection that the sum of the numbers in each column of the right-hand triangle is *equal* to the sum of the numbers in the corresponding row of the left-hand triangle; and that, therefore, the sum of all the numbers in the left-hand triangle is *equal* to the sum of all the numbers in the right-hand triangle, or equal to *one-half* the sum of all the numbers in the whole rectangle.

This will be true for a rectangle of any number of rows.

The sum of the numbers in each row of the left-hand triangle may be regarded as a term in a series of numbers, which, beginning at the bottom, is the series of natural numbers,

$$1, 2, 3, 4, \ldots\ldots\ldots n,$$

where n represents the highest term of the series under consideration; that is $n=1, 2, 3, 4 \ldots$, depending upon how far the triangle is extended. In the diagram drawn $n=6$. n also represents the number of the last column, represented in the left-hand triangle, counting from the left.

Now the sum of all the numbers in the whole rectangle of numbers is equal to the sum of the numbers in each row multiplied by the number of rows.

The sum of the numbers in each row of the rectangle is $n+1$; the number of rows is n.

Therefore the sum of all the numbers in the whole rectangle will be

$$S = n(n+1)$$

And the sum of all the numbers in the left-hand triangle will be

$$S = \frac{n(n+1)}{1 \cdot 2}$$

That is to say, the sum of the series $1, 2, 3, 4 \ldots n$ is

$$S = \frac{n(n+1)}{1 \cdot 2} \qquad (2)$$

If now we write a number of rows of the series 1, 2, 2, 4 . . .,

1	2	3	4	5	6	7	. . . . .
1	2	3	4	5	6	7	. . . . .
1	2	3	4	5	6	7	. . . . .
1	2	3	4	5	6	7	. . . . .
1	2	3	4	5	6	7	. . . . .
1	2	3	4	5	6	7	. . . . .

Table 2.

in the form of a rectangle, draw the zigzag diagonal, and divide the rectangle of numbers into two triangles as before, it becomes evident on inspection that the sum of the numbers in each column of the right-hand triangle is equal to *twice* the sum of the numbers in the corresponding row of the left-hand triangle; and that, therefore, the sum of all the numbers in the left-hand triangle is equal to *one-half* the sum of all the numbers in the right-hand triangle, or equal to *one-third* the sum of all the numbers in the whole rectangle.

As before, the sum of all the numbers in the whole rectangle of numbers is equal to the sum of all the numbers in each row multiplied by the number of rows.

The sum of the numbers in each row of the rectangle, by formula (2), if for n we put $n+1$, is $\frac{(n+1)(n+2)}{1 \cdot 2}$; the number of rows is n; therefore the sum of all the numbers in the whole rectangle will be

$$S = \frac{n(n+1)(n+2)}{1 \cdot 2}$$

and the sum of all the numbers in the left-hand triangle wiil be

$$S = \frac{n(n+1)(n+2)}{1 \cdot 2 \cdot 3} \qquad (3)$$

This expression, therefore, represents the sum of the series of numbers contained in the left-hand triangle, namely of the series

1, 3, 6, 10, 15, 21, 28 . . . . .

If now we write a number of rows of the series 1, 3, 6 . . .

1	3	6	10	15	21	28	. . . . .
1	3	6	10	15	21	28	. . . . .
1	3	6	10	15	21	28	. . . . .
1	3	6	10	15	21	28	. . . . .
1	3	6	10	15	21	28	. . . . .
1	3	6	10	15	21	28	. . . . .

Table 3.

in the form of a rectangle, draw the zigzag diagonal, and divide the rectangle of numbers into two triangles, as before, it becomes evident on inspection that the sum of the numbers in each column of the right-hand triangle is equal to *three times* the sum of the numbers in the corresponding row of the left-hand triangle, and that, therefore, the sum of all the numbers in the left-hand triangle in this case is equal to *one-third* the sum of all the numbers in the right-hand triangle, or equal to *one-fourth* the sum of all the numbers in the whole rectangle.

Again, by a process similar to the one used in the preceding case, the sum of all the numbers in the left-hand triangle becomes

$$S = \frac{n(n+1)(n+2)(n+3)}{1 \cdot 2 \cdot 3 \cdot 4} \qquad (4)$$

This expression, therefore, represents the sum of the series of numbers contained in the left-hand triangle, namely of the series

1, 4, 10, 20, 35, 56, 84 . . . .

Continuing this process precisely as before for the series 1, 4, 10, . . .

1	4	10	20	35	56	84	. . . . .
1	4	10	20	35	56	84	. . . . .
1	4	10	20	35	56	84	. . . . .
1	4	10	20	35	56	84	. . . . .
1	4	10	20	35	56	84	. . . . .
1	4	10	20	35	56	84	. . . . .

Table 4.

we obtain as the formula

$$S = \frac{n(n+1)(n+2)(n+3)(n+4)}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5} \tag{5}$$

for the sum of the series 1, 5, 15, 35, 70, 126, 210 . . . .

From

1	5	15	35	70	126	210	. . . . .
1	5	15	35	70	126	210	. . . . .
1	5	15	35	70	126	210	. . . . .
1	5	15	35	70	126	210	. . . . .
1	5	15	35	70	126	210	. . . . .
1	5	15	35	70	126	210	. . . . .

Table 5.

we obtain as formula

$$S = \frac{n(n+1)(n+2)(n+3)(n+4)(n+5)}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5 \cdot 6} \tag{6}$$

for the sum of the series 1, 6, 21, 56, 126, 252 . . . . .

We may proceed in this way indefinitely and thus obtain successively each of the series

		Index						
1st Order....	1	1	1	1	1	1	1	. . .
2nd Order....	1	2	3	4	5	6	7	. . .
3rd Order....	1	3	6	10	15	21	28	. . .
4th Order....	1	4	10	20	35	56	84	. . .
5th Order....	1	5	15	35	70	126	210	. . .
6th Order....	1	6	21	56	126	252	462	. . .
7th Order....	1	7	28	84	210	462	924	. . .
8th Order....	1	8	36	120	330	792	1716	. . .
	.	.	.	.	.	.	.	. . .

Table 6.

which are the series commonly known as *figurate numbers,*[2] defined by the property evident from inspection that the nth term in any series is equal to the sum of the first n terms of the series immediately preceding it. The nth term, therefore, of each of these series is indicated in the formula for the sum of the first n terms of the series immediately preceding, by which formula its structure is disclosed; so that these series may be written in the form

1	1	1	1	1	1
1	2	3	4	5	n
$\frac{1\cdot2}{1\cdot2}$	$\frac{2\cdot3}{1\cdot2}$	$\frac{3\cdot4}{1\cdot2}$	$\frac{4\cdot5}{1\cdot2}$	$\frac{5\cdot6}{1\cdot2}$	$\frac{n(n+1)}{1\cdot2}$
$\frac{1\cdot2\cdot3}{1\cdot2\cdot3}$	$\frac{2\cdot3\cdot4}{1\cdot2\cdot3}$	$\frac{3\cdot4\cdot5}{1\cdot2\cdot3}$	$\frac{4\cdot5\cdot6}{1\cdot2\cdot3}$	$\frac{5\cdot6\cdot7}{1\cdot2\cdot3}$	$\frac{n(n+1)(n+2)}{1\cdot2\cdot3}$
$\frac{1\cdot2\cdot3\cdot4}{1\cdot2\cdot3\cdot4}$	$\frac{2\cdot3\cdot4\cdot5}{1\cdot2\cdot3\cdot4}$	$\frac{3\cdot4\cdot5\cdot6}{1\cdot2\cdot3\cdot4}$	$\frac{4\cdot5\cdot6\cdot7}{1\cdot2\cdot3\cdot4}$	$\frac{5\cdot6\cdot7\cdot8}{1\cdot2\cdot3\cdot4}$ . . .	$\frac{n(n+1)(n+2)(n+3)}{1\cdot2\cdot3\cdot4}$
.	.	.	.	.	.

Table 7.

Inspection of Table 6 shows that the first column is identical with the first row; that the second column is identical with the second row; that the third column is

[2] See *Archiv der Mathematik und Physik,* I. **5**: 82–89, also "Figurate Series" B. B. Smyth, *Trans. Kansas Acad. Sci.* **14**: 29.

identical with the third row; and so on indefinitely; therefore, if we designate the general row by r as we have already designated the general column by n, we have as the formula for the general row expressed in terms of r and based upon its analogy with the nth column, the following:

$$1,\ r,\ \frac{r(r+1)}{1\cdot 2},\ \frac{r(r+1)(r+2)}{1\cdot 2\cdot 3},\ \frac{r(r+1)(r+2)\,r+3)}{1\cdot 2\cdot 3\cdot 4},\ \ldots\ldots \frac{r(r+1)(r+2)\ldots(r+n-2)}{1\cdot 2\cdot 3\ldots\ldots(n-1)} \tag{7}$$

in which formula, by giving r the successive values 1, 2, 3, ... we can obtain each of the rows of Table 6 in succession; or, by giving r any integral value whatever, we can obtain the series corresponding to the value of r chosen. The value of r, or the second number in any of the series may therefore be regarded as the *Index* of the series, and indicates the *Order* of the series.

As formula for the sum of any number of terms of the rth row, we have

$$S = \frac{n(n+1)(n+2)\ldots\ldots(n+r-1)}{1\cdot 2\cdot 3\ldots\ldots\ldots\ldots r}$$

$$\text{or,}\quad S = \frac{(r+1)(r+2)\ldots\ldots(r+n-1)}{1\cdot 2\cdot 3\ldots\ldots\ldots\ldots(n-1)}$$

If we now write the general row r a number of times, making a rectangle with its zigzag diagonal, two triangles, their respective rows and columns, as before,

1 r	$\frac{r(r+1)}{1\cdot 2}$	$\frac{r(r+1)(r+2)}{1\cdot 2\cdot 3}$	$\frac{r(r+1)(r+2)(r+3)}{1\cdot 2\cdot 3\cdot 4}$	. .
1 r	$\frac{r(r+1)}{1\cdot 2}$	$\frac{r(r+1)(r+2)}{1\cdot 2\cdot 3}$	$\frac{r(r+1)(r+2(r+3)}{1\cdot 2\cdot 3\cdot 4}$	. .
1 r	$\frac{r(r+1)}{1\cdot 2}$	$\frac{r(r+1)(r+2)}{1\cdot 2\cdot 3}$	$\frac{r(r+1(r+2)(r+3)}{1\cdot 2\cdot 3\cdot 4}$	. .
1 r	$\frac{r(r+1)}{1\cdot 2}$	$\frac{r(r+1)(r+2)}{1\cdot 2\cdot 3}$	$\frac{r(r+1)(r+2)(r+3)}{1\cdot 2\cdot 3\cdot 4}$	. .

Table 8.

it will be found in general that the sum of all the terms in each column of the right-hand triangle is equal to r times the sum of all the terms in the corresponding row of the left-hand triangle.

It will be noticed that in Table 6 the diagonals ascending from left to right give the coefficients of the ordinary binomial expansion with positive integral exponents, thus forming *Pascal's Triangle.*[3]

The explanation of this fact is at once seen from the structure of the terms of the different series as derived from the general expression given in (7). This procedure shows the structure of the several terms of each series, as follows:

1	1	$\frac{1\cdot2}{1\cdot2}$	$\frac{1\cdot2\cdot3}{1\cdot2\cdot3}$	$\frac{1\cdot2\cdot3\cdot4}{1\cdot2\cdot3\cdot4}$	. . . . .
1	2	$\frac{2\cdot3}{1\cdot2}$	$\frac{2\cdot3\cdot4}{1\cdot2\cdot3}$	$\frac{2\cdot3\cdot4\cdot5}{1\cdot2\cdot3\cdot4}$	. . . . .
1	3	$\frac{3\cdot4}{1\cdot2}$	$\frac{3\cdot4\cdot5}{1\cdot2\cdot3}$	$\frac{3\cdot4\cdot5\cdot6}{1\cdot2\cdot3\cdot4}$	. . . . .
.	.	.	.	.	. . . . .
1	$(r-4)$	$\frac{(r-4)(r-3)}{1\cdot2}$	$\frac{(r-4)(r-3)(r-2)}{1\cdot2\cdot3}$		. . . . .
1	$(r-3)$	$\frac{(r-3)(r-2)}{1\cdot2}$	$\frac{(r-3)(r-2)(r-1)}{1\cdot2\cdot3}$		. . . . .
1	$(r-2)$	$\frac{(r-2)(r-1)}{1\cdot2}$	$\boxed{\frac{(r-2)(r-1)r}{1\cdot2\cdot3}}$		. . . . .
1	$(r-1)$	$\boxed{\frac{(r-1)r}{1\cdot2}}$	$\frac{(r-1)r(r+1)}{1\cdot2\cdot3}$		. . . . .
1	$\boxed{r}$	$\frac{r(r+1)}{1\cdot2}$	$\frac{r(r+1)(r+2)}{1\cdot2\cdot3}$		. . . . .
$\boxed{1}$					

Table 9.

[3] Published by Pascal in his *Traité du triangle arithmétique*, 1665.

in which the diagonal indicated ascending from left to right gives the coefficients of the ordinary binomial expansion in terms of r.

Formula (7) is valid for negative as well as positive values of r, in fact, for all integral values of r from $-\infty$ to $+\infty$.

For values of r from 0 to $-\infty$ we obtain the different series indicated in Table 10[4] which is simply an extension of Table 6 upwards.

.	.	.	.	.	.	.	.	.	.
1	$\bar{6}$	15	$\overline{20}$	15	$\bar{6}$	1	.	.	.
1	$\bar{5}$	10	$\overline{10}$	5	$\bar{1}$	0	.	.	.
1	$\bar{4}$	6	$\bar{4}$	1	0	0	.	.	.
1	$\bar{3}$	3	$\bar{1}$	0	0	0	.	.	.
1	$\bar{2}$	1	0	0	0	0	.	.	.
1	$\bar{1}$	0	0	0	0	0	.	.	.
1	0	0	0	0	0	0	.	.	.
1	1	1	1	1	1	1	.	.	.
1	2	3	4	5	6	7	.	.	.
1	3	6	10	15	21	28	.	.	.
1	4	10	20	35	56	84	.	.	.
1	5	15	35	70	126	210	.	.	.
1	6	21	56	126	252	462	.	.	.
.	.	.	.	.	.	.	.	.	.

Table 10.

All the properties which have been described above as applicable to the different series with positive indices belong also to the portion of Table 10 with negative indices, as will be at once seen by trial.

[4] In Tables 10, 11, 12 and the following, negative values are indicated for convenience by minus signs placed above the numbers.

Since the corresponding rows and columns in Table 6 are identical, this table may be extended for negative values of n towards the left precisely in the same way as it was extended upwards in Table 10 for negative values of r, thus leading to Table 11.

. 1	1	1	1	1	1	1	1	1	1	1	1	1	.
. $\overline{6}$	$\overline{5}$	$\overline{4}$	$\overline{3}$	$\overline{2}$	$\overline{1}$	0	1	2	3	4	5	6	.
. 15	10	6	3	1	0	0	1	3	6	10	15	21	.
. $\overline{20}$	$\overline{10}$	$\overline{4}$	$\overline{1}$	0	0	0	1	4	10	20	35	56	.
. 15	5	1	0	0	0	0	1	5	15	35	70	126	.
. $\overline{6}$	$\overline{1}$	0	0	0	0	0	1	6	21	56	126	252	.
. .	.	.	.	.	.	.	.	.	.	.	.	.	.

Table 11.

It will be noticed that the defining property of the numbers in Pascal's triangle—namely, that the nth term in any series is equal to the sum of the first n terms of the preceding series—where n represents the number of the column, would be equally applicable if stated in terms of r, where r represents the number of the row; that is to say Table 11 becomes identical with Table 10, if in Table 11 each column is read from the top down and in Table 10 the corresponding row is read from left to right.

The relation of Tables 10 and 11 to each other is shown by their combination in Table 12.

							.	.	.	.	.	.	.	.
							.	.	.	.	.	.	.	.
							1	$\bar{5}$	10	$\bar{10}$	5	$\bar{1}$	0	.
							1	$\bar{4}$	6	$\bar{4}$	1	0	0	.
							1	$\bar{3}$	3	$\bar{1}$	0	0	0	.
							1	$\bar{2}$	1	0	0	0	0	.
							1	$\bar{1}$	0	0	0	0	0	.
							1	0	0	0	0	0	0	.
.	.	1	1	1	1	1	1	1	1	1	1	1	1	.
.	.	$\bar{5}$	$\bar{4}$	$\bar{3}$	$\bar{2}$	$\bar{1}$	0	1	2	3	4	5	6	7 .
.	.	10	6	3	1	0	0	1	3	6	10	15	21	28 .
.	.	$\bar{10}$	$\bar{4}$	$\bar{1}$	0	0	0	1	4	10	20	35	56	84 .
.	.	5	1	0	0	0	0	1	5	15	35	70	126	210 .
.	.	$\bar{1}$	0	0	0	0	0	1	6	21	56	126	252	462 .
.	.	.	.	.	.	.	.	.	.	.	.	.	.	. .

Table 12.

It is interesting to note that every one of the series in Table 10 represents the expansion of the expression

$$(1-1)^{-r}$$

by giving to r its appropriate value as shown by the index of the series, that is, by the number of the row, for negative as well as positive values; and that similarly every one of the series in Table 11, reading from the top downwards, represents the expansion of the expression

$$(1-1)^{-n}$$

by giving to n its appropriate value as shown by the number of the column, for negative as well as positive values.

The foregoing set of series of *figurate numbers* may be regarded as a *special case;* but the method described may be extended to *more general cases* as follows:

A. If instead of Table 6 we write

(a)	1	$1+d$	$1+d$	$1+d$	$1+d$	.	.	.
(b)	1	$2+d$	$3+2d$	$4+3d$	$5+4d$	.	.	.
(c)	1	$3+d$	$6+3d$	$10+6d$	$15+10d$	.	.	.
(d)	1	$4+d$	$10+4d$	$20+10d$	$35+20d$	.	.	.
	.	.	.	.	.	.	.	.

Table 13.

where d is any integer, it will be seen that in this set of series, the nth term of any series is equal to the sum of the first n terms of the preceding series, and that the definition of *figurate numbers* is therefore satisfied. In this set each of the rows may be separated into two series whose sum is the sum of the corresponding series in the table.

Thus the series (a), (b), (c), (d) may be written

(a)	(1	1	1	1	1	.	.)	+	(0	1	1	1	1	.	.)	d
(b)	(1	2	3	4	5	.	.)	+	(0	1	2	3	4	.	.)	d
(c)	(1	3	6	10	15	.	.)	+	(0	1	3	6	10	.	.)	d
(d)	(1	4	10	20	35	.	.)	+	(0	1	4	10	20	.	.)	d
	.	.	.	.	.	.	.		.	.	.	.	.	.	.	

For the sum of (a) we have by (1)

$$S = n+(n-1)d \tag{8}$$

For the sum of (b) we have by (2)

$$S = \frac{n\,(n+1)}{1\cdot 2} + \frac{(n-1)\,n}{1\cdot 2}\,d \tag{9}$$

For the sum of (c) we have by (3)

$$S = \frac{n\,(n+1)\,(n+2)}{1\cdot 2\cdot 3} + \frac{(n-1)\,n\,(n+1)}{1\cdot 2\cdot 3}\,d \tag{10}$$

For the sum of (d) we have by (4)

$$S = \frac{n\ (n+1)\ (n+2)\ (n+3)}{1 \cdot 2 \cdot 3} + \frac{(n-1)\ n\ (n+1)\ (n+2)}{1 \cdot 2 \cdot 3 \cdot 4}\ d \qquad (11)$$

For $d=\bar{3}$, these series become

1	$\bar{2}$	$\bar{2}$	$\bar{2}$	$\bar{2}$	.	.	.
1	$\bar{1}$	$\bar{3}$	$\bar{5}$	$\bar{7}$	.	.	.
1	0	$\bar{3}$	$\bar{8}$	$\overline{15}$	.	.	.
1	1	$\bar{2}$	$\overline{10}$	25	.	.	.
.	.	.	.	.	.	.	.

Table 14.

For $d=\bar{2}$,

1	$\bar{1}$	$\bar{1}$	$\bar{1}$	$\bar{1}$	.	.	.
1	0	$\bar{1}$	$\bar{2}$	$\bar{3}$	.	.	.
1	1	0	$\bar{2}$	$\bar{5}$	.	.	.
1	2	2	0	$\bar{5}$	.	.	.
.	.	.	.	.	.	.	.

Table 15.

For $d=\bar{1}$,

1	0	0	0	0	.	.	.
1	1	1	1	1	.	.	.
1	2	3	4	5	.	.	.
1	3	6	10	15	.	.	.
.	.	.	.	.	.	.	.

Table 16.

which is identical with Table 6.

For $d=0$,

1	1	1	1	1	.	.	.
1	2	3	4	5	.	.	.
1	3	6	10	15	.	.	.
1	4	10	20	35	.	.	.
.	.	.	.	.	.	.	.

Table 17.

which is identical with Table 6 and Table 16.

For $d=1$,

1	2	2	2	2	.	.	.
1	3	5	7	9	.	.	.
1	4	9	16	25	.	.	.
1	5	14	30	55	.	.	.
.	.	.	.	.	.	.	.

Table 18.

For $d=2$,

1	3	3	3	3	.	.	.
1	4	7	10	13	.	.	.
1	5	12	22	35	.	.	.
1	6	18	40	75	.	.	.
.	.	.	.	.	.	.	.

Table 19.

For $d=3$,

1	4	4	4	4	.	.	.
1	5	9	13	17	.	.	.
1	6	15	28	45	.	.	.
1	7	22	50	95	.	.	.
.	.	.	.	.	.	.	.

Table 20.

B. Or again, instead of Table 6 we may write

(e)	1	$1+d$	$1+2d$	$1+3d$	.	.	.
(f)	1	$2+d$	$3+3d$	$4+6d$	.	.	.
(g)	1	$3+d$	$6+4d$	$10+10d$	.	.	.
(h)	1	$4+d$	$10+5d$	$20+15d$	.	.	.
	.	.	.	.	.	.	.

Table 21.

where d is any integer. It will be seen that in this set of series, also, the nth term of any series is equal to the

sum of the first n terms of the preceding series. In this case the expressions for the sums become:

For (e), by (1) and (2)

$$S = n + \frac{(n-1)n}{1 \cdot 2} d \tag{12}$$

For (f), by (2) and (3)

$$S = \frac{n\ (n+1)}{1 \cdot 2} + \frac{(n-1)\ n\ (n+1)}{1 \cdot 2 \cdot 3} d \tag{13}$$

For (g), by (3) and (4)

$$S = \frac{n(n+1)(n+2)}{1 \cdot 2 \cdot 3} + \frac{(n-1)n(n+1)(n+2)}{1 \cdot 2 \cdot 3 \cdot 4} d \tag{14}$$

For (h), by (4) and (5)

$$S = \frac{n(n+1)(n+2)(n+3)}{1 \cdot 2 \cdot 3 \cdot 4} + \frac{(n-1)n\,(n+1)\,(n+2)(n+3)}{1 \cdot 2 \cdot 3 \cdot 4 \cdot 5} d \tag{15}$$

For $d = \bar{3}$, these series become

1	$\bar{2}$	$\bar{5}$	$\bar{8}$	$\overline{11}$	.	.	.
1	$\bar{1}$	$\bar{6}$	$\overline{14}$	$\overline{25}$	.	.	.
1	0	$\bar{6}$	$\overline{20}$	$\overline{45}$	.	.	.
1	1	$\bar{5}$	$\overline{25}$	$\overline{70}$	.	.	.
.	.	.	.	.	.	.	.

Table 22.

For $d = \bar{2}$,

1	$\bar{1}$	$\bar{3}$	$\bar{5}$	$\bar{7}$	.	.	.
1	0	$\bar{3}$	$\bar{8}$	$\overline{15}$	.	.	.
1	1	$\bar{2}$	$\overline{10}$	$\overline{25}$	.	.	.
1	2	0	$\overline{10}$	$\overline{35}$	.	.	.
.	.	.	.	.	.	.	.

Table 23.

which is identical with Table 14.

For $d=\bar{1}$,

1	0	$\bar{1}$	$\bar{2}$	$\bar{3}$	.	.	.
1	1	0	$\bar{2}$	$\bar{5}$	.	.	.
1	2	2	0	$\bar{5}$	.	.	.
1	3	5	5	0	.	.	.
.	.	.	.	.	.	.	.

Table 24.

which is identical with Table 15.

For $d=0$,

1	1	1	1	1	.	.	.
1	2	3	4	5	.	.	.
1	3	6	10	15	.	.	.
1	4	10	20	35	.	.	.
.	.	.	.	.	.	.	.

Table 25.

which is identical with Table 6, Table 16, and Table 17.

For $d=1$,

1	2	3	4	5	.	.	.
1	3	6	10	15	.	.	.
1	4	10	20	35	.	.	.
1	5	15	35	70	.	.	.
.	.	.	.	.	.	.	.

Table 26.

which is identical with Table 6, Table 16, Table 17, and Table 25.

For $d=2$,

1	3	5	7	9	.	.	.
1	4	9	16	25	.	.	.
1	5	14	30	55	.	.	.
1	6	20	50	105	.	.	.
.	.	.	.	.	.	.	.

Table 27.

which is identical with Table 18.

For $d=3$,

1	4	7	10	13	.	.	.
1	5	12	22	35	.	.	.
1	6	18	40	75	.	.	.
1	7	25	65	140	.	.	.
.	.	.	.	.	.	.	.

Table 28.

which is identical with Table 19.

The set of series included in Table 21 is of peculiar interest because it contains the familiar sets of series known as *polygonal numbers* and *pyramidal numbers.*

Polygonal numbers. These are the numbers in the second row of Table 21, for d=successively 1, 2, 3, 4 . . . .

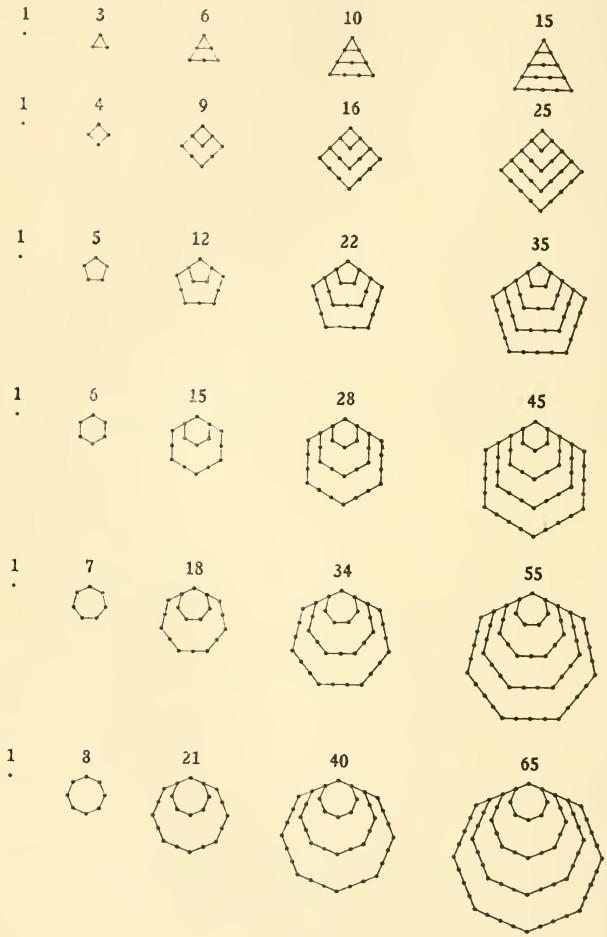
For $d=1$,	1	3	6	10	.	.	(Triangular)
$d=2$,	1	4	9	16	.	.	(Square)
$d=3$,	1	5	12	22	.	.	(Pentagonal)
$d=4$,	1	6	15	28	.	.	(Hexagonal)
$d=5$,	1	7	18	34	.	.	(Heptagonal)
$d=6$,	1	8	21	40	.	.	(Octagonal)
	.	.	.	.	.	.	

Table 29.

They are called *polygonal* because the numbers in the series correspond to the numbers of points or dots which

[5] See "Ueber polydimensionalen Zahlenfiguren", by Th. Harmuth, *Archiv der Mathematik und Physik*, Series I, Vol. LXIX, pp. 90–107.

can be arranged in the form of regular polygons of 3, 4, 5, ... sides for the respective cases, thus:



Pyramidal numbers. These are the numbers in the third row of Table 21 for d=successively 1, 2, 3, ...

For d=1,	1	4	10	20	.	.	(Triangular Pyramid)
d=2,	1	5	14	30	.	.	(Square Pyramid)
d=3,	1	6	18	40	.	.	(Pentagonal Pyramid)

They are called *pyramidal* because the numbers correspond to the numbers of points or dots which can be arranged in the form of regular pyramids with the regular polygons of 3, 4, 5 . . . sides for the bases in the respective cases.

Evidently an indefinite number of sets of series comparable with the above may be obtained by varying the combination of the columns involving d with the columns of Table 6. Two such sets of series have been exhibited in Tables 13 and 21.

All such sets of series will satisfy the definition of *figurate numbers.* The numbers of such series is infinite.

But it should be noted that the definition of *figurate numbers* usually given, namely that the nth term of any series is equal to the sum of the first n terms of the preceding series, applies also to an infinite number of other sets of series not included among those previously indicated and not usually classed as *figurate numbers.* Such, for example, is the set of series, arbitrarily chosen,

.	.	.	.	.	.	.	.
3	$\overline{4}$	5	$\overline{6}$	5	.	.	.
3	$\overline{1}$	4	$\overline{2}$	3	.	.	.
3	2	6	4	7	.	.	.
3	5	11	15	22	.	.	.
3	8	19	34	56	.	.	.
.	.	.	.	.	.	.	.

Table 30.

which may be extended up and down indefinitely. Evidently from any arbitrary series of integers, such a set

of series may be derived by applying the property named, thus:

If $a, b, c, d, \ldots$ represent any series of integers, positive or negative, the set of series in which the nth term of any series is equal to the sum of the first n terms of the preceding series will be:

a	b	c	d	. . .
a	$a+b$	$a+b+c$	$a+b+c+d$	. . .
a	$2a+b$	$3a+2b+c$	$4a+3b+2c+d$	. . .
a	$3a+b$	$6a+3b+c$	$10a+6b+3c+d$	. . .
a	$4a+b$	$10a+4b+c$	$20a+10b+4c+d$	. . .
.	.	.	.	. . .

Table 31.

Table 31 may be arranged diagrammatically as in Table 32.

$$\begin{bmatrix} . & . & . & . & . & . \\ 1 & 0 & 0 & 0 & . & . \\ 1 & 1 & 1 & 1 & . & . \\ 1 & 2 & 3 & 4 & . & . \\ 1 & 3 & 6 & 10 & . & . \\ 1 & 4 & 10 & 20 & . & . \\ . & . & . & . & . & . \end{bmatrix} a + \begin{bmatrix} . & . & . & . & . & . \\ 0 & 1 & 0 & 0 & . & . \\ 0 & 1 & 1 & 1 & . & . \\ 0 & 1 & 2 & 3 & . & . \\ 0 & 1 & 3 & 6 & . & . \\ 0 & 1 & 4 & 10 & . & . \\ . & . & . & . & . & . \end{bmatrix} b +$$

$$+ \begin{bmatrix} . & . & . & . & . & . \\ 0 & 0 & 1 & 0 & . & . \\ 0 & 0 & 1 & 1 & . & . \\ 0 & 0 & 1 & 2 & . & . \\ 0 & 0 & 1 & 3 & . & . \\ 0 & 0 & 1 & 4 & . & . \\ . & . & . & . & . & . \end{bmatrix} c + \begin{bmatrix} . & . & . & . & . & . \\ 0 & 0 & 0 & 1 & . & . \\ 0 & 0 & 0 & 1 & . & . \\ 0 & 0 & 0 & 1 & . & . \\ 0 & 0 & 0 & 1 & . & . \\ 0 & 0 & 0 & 1 & . & . \\ . & . & . & . & . & . \end{bmatrix} d + \ldots$$

Table 32.

in which the coefficients of the different letters are collected, series for series, and inclosed in brackets. It will be seen that the sets of series in the brackets are identical in form with Table 6, and differ from each other only in the number and position of the significant columns. Formulæ for the sums of these series may therefore at once be written by the methods already given, and the relation of *the general case* exhibited in Table 31 to the ordinary *figurate numbers* of Table 6 becomes clear.

By assigning special values to $a, b, c, d, \ldots$ in Table 31 or Table 32 all the preceding sets of series may be obtained.

Thus for $a=1$, and $b=c=d=\ldots=0$, Table 31 becomes Table 6.

For $a=1$, and $b=c=d=\ldots=1+d$, Table 31 becomes Table 13.

For $a=1$, and $b=c=d=\ldots=d$, Table 31 becomes Table 21.

For $a=3$, $b=\overline{4}$, $c=5$, $d=\overline{6}$, $e=5$, . . . Table 31 becomes Table 30.

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HERPETOLOGY OF MISSOURI.

JULIUS HURTER, Sr.

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Continued on page 3 of Cover.

HERPETOLOGY OF MISSOURI.*

JULIUS HURTER, SR.

The aim of this paper is to give as complete and thorough a presentation of the Amphibian and Reptilian fauna of the State of Missouri as possible. Students of Herpetology labor under many disadvantages as the descriptions of North American Amphibia and Reptilia are scattered through many works, generally found only in large scientific libraries.

Some of our adjoining states—Illinois, Nebraska, Kansas, and, lately, Arkansas[1]—have published lists of the species occurring within their respective limits. This is the first attempt at compiling a list for the State of Missouri. Most of it is based upon my own observations during the past twenty-seven years and those of my two sons, Julius and Henry, and my grandson, Arthur Weinzettel.

The great drawback to collecting reptiles and in acquiring accurate information concerning their habits and habitats is the fear most people have of these animals, partly because of the appearance of some and the supposed poisonous character of many. In reality there are only six species in the state which are poisonous—all among the snakes—while all others (96 species) are absolutely harmless and more or less beneficial to agriculture.

I take this opportunity to express my sincere thanks to Dr. Leonhard Stejneger, Curator of Reptiles in the National Museum at Washington, D. C., and to Mr. Arthur Erwin Brown, Director of the Zoological Gar-

*Presented in abstract before the Academy of Science of St. Louis, November 7, 1910.

[1] Trans. Acad. Sci. St. Louis 18: 11-27. 1909.

den in Philadelphia, for their valuable aid in determining many doubtful cases of identification.

To the following ladies and gentlemen I am indebted for annotated lists of specimens found in their respective counties, as well as for the presentation of specimens.

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Warren Co.; Mr. J. J. Bodenburg, Illinois; Mr. T. Van Hyning, Iowa; Mr. J. J. Black, Baxter Springs, Kansas; and Mr. J. R. Fordyce, Little Rock, Arkansas.

With regard to the nomenclature of families, genera, and species, I have adhered strictly to the "International Rules of Zoological Nomenclature," adopted by the International Congress of Zoology.[2] As Dr. Stejneger remarks in his Herpetology of Japan, "changes in nomenclature necessitated by these rules, therefore, must not be laid to any desire of the author to alter names, but to the necessity of conforming strictly to the laws now generally accepted by the working zoologists of the world."

Directions for Collecting and Preserving Amphibians and Reptiles.

When and where to collect.—While amphibians and reptiles may be found occasionally in any season, spring is the time for collecting. In a moderately cold climate toads and salamanders may be looked for on the first warm day, signaling the breaking up of winter. Reptiles, as a rule, require warmer weather to rouse them from their winter homes.

Lizards, snakes, toads, frogs and salamanders are mostly found under fallen logs and rocks. Salamanders, frogs and toads are found in damp, shady places near springs, creeks, and ponds, whereas snakes and lizards are mostly found on the southern slopes of hill sides and in or near water.

How to secure the specimen.—Most reptiles and amphibians are easily caught by hand, but some reptiles are either so quick in their movements or so shy that other devices must be resorted to. Turtles may be caught with hook and line, baited with raw meat or liver, or with a dip net. Lizards and frogs may be shot with No. 12

[2] Règles Internationales de la Nomenclature Zoologique adoptées par les Congrès Internationaux de Zoologie. Paris. 1905.

shot. In spring farmers often plow up snakes, lizards and salamanders.

An old style fish bucket with a perforated inside pocket is the best thing to carry home the catch alive. There should also be separate receptacles for emergency. Toads, frogs and salamanders must be moistened occasionally to keep them alive. Specimens that have been shot and killed should be placed in the preserving fluid at once. A pair of pinchers or tongs, made of two half-round sticks about three feet long, with a screw as a fulcrum about six inches from one end, is very serviceable in catching poisonous snakes. All the Pit Vipers, such as Copperheads, Cottonmouths, and Rattlesnakes, may be picked up by the tail and dropped into a bucket, which, of course, must be closed very quickly. These snakes are too clumsy to reach the hands quickly.

The preserving fluid.—Either alcohol or formaldehyde (also called formalin) should be used for preserving. Mix one pint of clean water with one ounce of formaldehyde. This mixture is strong enough to preserve snakes, lizards and turtles. For frogs, toads and salamanders mix ¾ ounce of formaldehyde with one pint of water. If alcohol is used, take it as strong as you can get it for snakes, lizards and turtles, but for salamanders, toads and frogs use only a mixture of half alcohol and half water. Two tablespoonsful of formaldehyde is equal to one ounce.

How to kill the specimen.—The easiest and quickest way to kill a turtle, lizard, snake, toad, or large frog is with a 40% solution of formaldehyde injected hypodermically near the heart. Even a four or five feet snake will be dead in five or ten minutes. For salamanders and small frogs an 8% solution is sufficient.

How to prepare and preserve the specimen.—After the animal is dead it should be placed in a flat-bottomed receptacle, such as a soup plate, in the desired position.

In an hour and a half or two the specimen will be stiff and retain the position first given it. In large snakes—about ¾ inch thick and two or more feet long—the liquid should be injected at intervals of about three inches. By injecting behind the vent the copulating organs are generally brought out in the male. Always inject the tail of snakes, but not that of lizards. Turtles, after death, should have the head, feet and tail drawn out from the shell and the mouth opened by placing a small piece of wood between the jaws. After the specimen has been prepared as given above, it should be placed in the preserving fluid in a glass or earthenware jar. Never crowd too many specimens into one receptacle.

How to pack and ship specimens.—Specimens, after being immersed in the preserving fluid for one or two weeks, according to size, will be sufficiently hardened to stand transportation for a considerable distance in a damp state. A cigar box or a baking powder can will answer very well for small shipments by mail. Wrap the reptile in cotton batting, soak it in the preserving fluid and squeeze out most of it, taking care, however, not to press the specimen too much. Then place the specimen solidly in the box, but not too tightly, and wrap several thicknesses of strong paper around the parcel.

Harmless specimens.—The following reptiles are non-poisonous and may be handled with impunity. All toads, frogs, salamanders, water dogs, and mud puppies, all lizards and all turtles, and all snakes with the exception of Coral Snakes, Copperheads, Cottonmouths, and Rattlesnakes, which are poisonous and should be handled with the greatest care.

Class **Amphibia.**

The amphibians, or batrachians, as they are also called, are anamniote, archaecraniate, and stomatophysous vertebrates possessing a well-developed skull provided with a lower jaw and articulating with the vertebral column by means of two occipital condyles; limbs, when not atrophied, consisting of humerus or femur followed by two propodials

(radius and ulna, tibia and fibula), metapodials (carpals and metacarpals, tarsals and metatarsals), and digits (phalanges); heart with three chambers; internal nares; respiration, at least during part of life, by means of gills; skin naked. Young, usually after leaving egg, undergoes a metamorphosis. (Stejneger.)

This class includes three recent orders, namely, the Caecilians (Apoda), the Salamanders (Caudata), and the Frogs (Salientia). Of these only the two latter orders are represented within our present limits.

Order CAUDATA.

Amphibia having a lizard-like, eel-like, or serpent-like form. At least the fore limbs and the shoulder girdle are present in all forms; and usually also the hind limbs. Posterior limbs never conspicuously larger than the anterior. Proximal elements of the tarsus not elongated. Vertebrae numerous, at least 14 in front of the sacrum; these either amphicœlous or opisthocœlous. Ribs present, short. Maxilla present in all, except *Necturus* and *Siren*. Teeth present on maxillaries, vomero-palatines, and on the dentaries, except in *Siren*. No tympanic cavities or eustachian tubes. Cloaca opening externally by a longitudinal slit. (Hay.)

This order is divided into three suborders, viz., the Mudpuppies (Proteida), the Sirens (Meantes), and the true Salamanders (Mutabilia).

So far nineteen species have been found in Missouri.

Suborder PROTEIDA.

The suborder Proteida may be defined as follows: No median sternal elements. Vertebrae amphicœlous. Carpus and tarsus cartilaginous. Inner walls of vestibule osseous. Nasalia wanting. Teeth on all the usual bones except the maxillaries, which are wanting. The second ceratobranchial is generally present, as in Mutabilia. Stapes directly connected with the suspensorium. (Cope.)

Of this suborder but three genera are known, *Necturus* and *Typhlomolge* of North America, and *Proteus* of Europe.

Genus NECTURUS.

Vomero-palatine teeth in a single series. Three persistent branchial arches. Tongue large and fleshy, free in front and on the sides. Eyes small and distinct. Vertebrae amphicœlous. Carpus and tarsus cartilaginous. Head elongate. Trunk short, thick. Fingers and toes four.

1. NECTURUS MACULOSUS Rafinesque. Water Dog. Mud Puppy.

Salamandra, Proteus tetradactylus, Sirena maculosa, Triton lateralis, Menobranchus tetradactylus, Menobranchus lateralis, Menobranchus maculatus, Proteus maculatus, Necturus lateralis. Furchenmolch, Necturus maculatus.

Description.—Head flat, oval; snout truncated. A groove along the middle of the back and a well-marked gular fold. Large bushy gills, forming three tufts on each side of the head. The eyes, situated anterior to the middle of the head, are rather small. Nostrils small and situated near the border of the lips. The upper lip is rather full and has a thin edge which overhangs the lower lip, concealing the posterior part of it. The tongue does not reach the symphysis of the lower jaw, and is obtusely rounded in front and considerably free anteriorly. The internal nares form an oblique slit on each side and lie obliquely between the vomerine and pterygoid teeth. The premaxillary teeth are in two straight, divergent series, which unite in front in a round point, and form not quite a right angle. The vomerine series of teeth is parallel with the premaxillary. Limbs short, about equal in length, digits slightly depressed. Tail much compressed, finned, with the end rounded. Skin smooth.

Color.—Light brown to dark brown, lighter beneath with more or less distinct roundish black spots. Soles and palms yellowish. In young specimens, less than 155 mm. long, a dark brownish band passes along the canthus rostralis through the eye and along the sides to near the end of the tail.

Size.—The largest specimen in my collection is 390 mm. long; the smallest, a larva, 20 mm. long.

Habitat.—The species ranges throughout the tributaries of the Great Lakes, the Mississippi River, and Lake Champlain. Mr. R. R. Rowley of Louisiana, Pike Co., Mo., presented me with a fine adult specimen from that neighborhood. I can record the capture of this species from the following counties and rivers:—Butler, Stoddard, St. Louis, and Jackson Counties; Mississippi, Missouri, Meramec, and St. Francis Rivers, and Spring River in Jasper Co.

Habits.—In Spring and Fall this species is often caught by fishermen with hook and line baited with worms.—Feb. 19; Apr. 3; Oct. 6; Nov. 23. They feed upon worms and larvae of water insects. I had two adult specimens

which I kept and observed for a long time, but one morning I found both dead, the larger one having partly swallowed the smaller one. They often have their gills without fibrillae and live then by cutaneous and pulmonary respiration. They are very hardy, having been frozen and thawed out several times during a winter, according to Mr. Samuel Kneeland. They are most active at night and avoid daylight.

Suborder MEANTES.

This suborder may be defined as follows: Tongue, covering the floor of the mouth, free in front. Jaws with a horny sheet. Vomerine teeth numerous, forming two large patches converging anteriorly. Spiraculae, three on each side below the gills, of which there are three on each side also. Only two limbs in front. Four fingers.

Family SIRENIDAE.

Posterior legs and the pelvic bones wanting. Anterior legs with three or four digits. Jaws provided with horny plates instead of teeth. Vomerine teeth in two large divergent patches. Three persistent branchial tufts, with three corresponding free arches across the branchial openings and a fourth arch bound in the integument. Occipital condyles sessile. Carpus cartilaginous. Vertebrae amphicœlian. (Garman.)

This family includes but two genera, both American,—*Pseudobranchus* and *Siren*. Only the latter genus has so far been found in the State of Missouri.

Genus SIREN.

Body long and slender. Mouth small, inferior. Tongue free in front and slightly so at sides. Internal nares outside the patches of teeth. Branchial tufts fimbriated. Tail short, compressed, with a dorsal membrane. (Garman.)

This genus includes but a single species described below.

2. SIREN LACERTINA Linn. Siren. Two-legged Eel. Mud-Eel.

Mud Iguana, Muracna siren, Sirène lacertine, Siren operculata, Sirène.

Description.—Slender and eel-like. Head rather small. Eyes small. Snout slightly rounded, almost truncate. Nostrils inferior, near the

tips of the snout widely separated. Mouth small, inferior, transverse; lower lip marked off by a groove. Lower jaws provided with a black, corneous, sharp-edged covering, like the jaws of tadpoles, in place of teeth. Upper jaw with a similar but smaller plate. Vomerine teeth in two large oblique patches. Three coarsely fimbriate branchial tufts. Branchial openings not large, covered by three free arches, bearing at their inner margins series of short cartilaginous tubercles. The single pair of legs is placed close behind the head. They are rather weak and bear four small digits, which have whitish, sometimes dark, horny tips resembling claws. (Garman.)

The skin is everywhere perfectly smooth. The tail is compressed from the base to the extremity, and for its distal half is quite thin. It has a strong dermal fin above and below. It commences above opposite to the anterior extremity of the vent, and from the rear end of the vent to the end of the tail. (Cope.)

Color. In living specimens.—Above brown, interspersed with innumerable darker, roundish spots, not over one millimeter in diameter. Below lead color, closely sprinkled with very small blackish dots. A yellowish band with irregular or poorly defined outline extends around the muzzle and upper lip to the branchial tufts, and below them around the base of the arms. In some of them the inner side of the arms and the lower side of the hands are also yellowish, with the corneous tips of the fingers brownish. In some specimens there is only a short yellowish streak on the cheeks.

Size.—My largest specimen is 360 mm. long, or 260 mm. from the end of the snout to the posterior end of the vent, and 100 mm. to the end of the tail.

Habitat.—Dr. Cope states that the geographical range of the Siren is the best measure of the extent of the austroriparian region of North America. It appears in eastern North Carolina, and extends thence throughout the Southern Atlantic and Gulf States through Texas to the west side of the Rio Grande, where it ceases. Northward it ascends the Mississippi Valley proper as far as Alton, Ill.; eastward in the Wabash basin and White River Valley. In the eastern part of Arkansas, in the sunken lands, and in the eastern counties of Missouri as far as St. Louis and Lincoln Counties, as well as in Union, Randolph, Monroe, St. Clair, and Madison Counties, Ill., it is often encountered.

Habits.—Sirens feed on worms and minnows. Most of those in my possession were caught with hook and line

baited with worms. When kept in an aquarium they always seek the darkest place in it. After the receding of the high water in Spring, they are most numerous. In the year 1909, when a canal was being dredged to drain the many lakes and sloughs in the so-called "American Bottom", opposite St. Louis, Sirens were more numerous than ever before. I think they had been driven out of their regular resorts by these operations. In the winter of 1904-05, when the temperature went down to 15 degrees below zero, an acquaintance of mine reported that he saw hundreds of them frozen in the ice. He did not send me any as he thought I only wanted live specimens. When the ice thawed, they were eaten by the crows. To all appearances they are not very scarce and it is only because of their habits—living mostly in the mud—that they are not found oftener.

Dates of capture.—I have specimens which were caught Apr. 8, May 3, and June 13. Mr. B. H. Pluempe presented me with a living specimen which he caught in Gingrass Creek, North St. Louis.

Suborder MUTABILIA.

The true salamanders are divided into two superfamilies, viz., the Amphiumoideae and the Salamandroideae. For our present purpose it is enough to separate them by the presence of well-developed eyelids in the latter and the absence of eyelids in the former. It is stated that the absence of eyelids is concurrent with the absence of a first epibranchial and with the connection of stapes with the quadrate arch in the Amphiumoideae, while in the Salamandroideae a first epibranchial is present and stapes not connected with the quadrate arch in the adult. (Stejneger.)

Both superfamilies occur within the State of Missouri.

Superfamily Amphiumoideae.

Two families compose the superfamily Amphiumoideae, the Amphiumidae and the Cryptobranchidae, differing in many anatomical characters, the former represented by the eel-like *Amphiuma* with at most three digits on the rudimentary legs, the latter by the hell-bender, with its more salamander-like body, 4-5 digits and well-developed limbs. The former occurs only in North America. (Stejneger.)

Family Amphiumidae.

No eyelids. Body elongated and eel-like. Two pairs of limbs, feebly developed. Two or three digits on each limb. A single branchial slit on each side of the neck. Teeth of maxillary and vomero-palatine in two parallel, backwardly directed series along each upper jaw. Premaxillaries united, developed from a single center, sending back two strong processes, one in the roof of the mouth, the other between the nasals and frontals on the upper surface of the snout. Vertebrae amphicoelous. Carpus and tarsus cartilaginous.

3. Amphiuma means Linn. Congo-Eel. Congo Snake.

Sirena simile, Chrysodonta larvaeformis, Sirenoides didactylum, Amphiuma means s. didactyla, Amphiuma didactyla, Amphiuma didactyla et tridactylum, Amphiuma tridactyla, Muracnopsis tridactylus.

Description.—Body long and eel-like. Head narrower and more pointed than is usual among the amphibians. A single gill-slit on each side. Eyes very small, covered by the skin. No external gills in adults. Fore and hind limbs present, extremely feeble. Digits on feet variable, usually two or three. Length of head (snout to gill-clefts), about ten times in length from snout to vent. Tail about one-fourth the total length, compressed, slender and pointed. Skin smooth. (Hay.)

Color.—Dark slaty or reddish brown, paler below. Lower jaw and edge of upper lip yellowish.

Size.—Congo Snakes may reach a length of three feet—914 mm.

Habitat.—Found from the Carolinas west to Louisiana and up the Mississippi River as far north as Pemiscot (Dr. Kingsolving) and Dunklin Counties in Missouri. I have in my collection specimens from Little Rock, Ark., but have never had the luck to collect one in Missouri.

Habits.—The Congo Snake is a mud-loving animal, its whole structure being adapted to burrowing in the mud at the bottom of sloughs, creeks, and rivers. When in New Orleans a few years ago, I caught several specimens after a heavy rain in the gutters of the streets in the outskirts of the city. The food of these salamanders consists of all kinds of aquatic animals, small fish, beetles, and mollusks. I never saw the pair from New Orleans, which I kept in my aquarium for a whole season, eat any-

thing, but still when I killed them they were plump and fat.

Congo Snakes are remarkable for the size of their blood corpuscles, the largest furnished by any vertebrate, being visible to the naked eye. The number of their vertebrae is also worthy of remark, there being altogether about 110, of which 65 lie in front of the sacrum. (Hay.)

Family Cryptobranchidae.

Form salamandrine. Head broad and depressed, mouth wide. Limbs four, well-developed. Tail broad and compressed. Teeth on the anterior edge of vomers, concentric with those of the premaxillaries and maxillaries, but not extending so far back as the latter. No teeth on parasphenoids. Tongue large, free in front. (Hay.)

This family embraces three genera, *Proteocordylus* (*Andrias*), known only from the Miocene of western Europe, *Cryptobranchus*, which only occurs in eastern North America, and *Megalobatrachus*, known from Japan and China. (Stejneger.)

4. Crytobranchus alleghaniensis Daudin. Hellbender. Mud-Devil.

Salamandra alleghaniensis, Salamandra gigantea, Protonopsis horrida, Abranchus alleghaniensis, Salamander des monts alleghaniens, Menopoma alleghaniensis, Cryptobranchus horridus, Menopoma alleghaniense.

Description.—Size large, body heavy and depressed. Head broad and flat and snout rounded. Tail broad and much depressed, with a fin along its upper edge; its length equal to half the remainder of the animal. Skin richly provided with mucous follicles, especially about the head. Sides with a conspicuous, corrugated cutaneous fold, which extends from the angle of the mouth to the middle of the tail.

Mouth large, the gape extending to behind the eyes. Nostrils small, close to the edge of the lips. Eyes small, with no evident lids. Limbs short and stout, bordered externally by a fold of membrane, which extends down to the outer toe. Hind limbs stoutest, and bordered behind by a second fold, which, near the foot, passes into the external fold. Digits 4-5. The distance from the snout to the gill-slit is equal to about one-sixth or nearly one-seventh of the total length. (Hay.)

Color.—The usual color is a rather light lead to yellowish clay, paler beneath. Some specimens, particularly the younger ones, have

dark brown spots and blotches irregularly distributed over the whole back and sides of the tail, where, as in the others, these spots are very indistinct and sometimes entirely absent. Cope states that some specimens are almost entirely black.

Size.—A specimen in my collection from the Ohio River measures 435 mm. total length, tail 165 mm. One from the Gasconade River, Mo., measures 430 mm., tail 140 mm.

Habitat.—The species is distributed from western New York, Pennsylvania, and the Great Lakes to Iowa, south to Georgia, North Carolina, and Louisiana. I have specimens from the Gasconade, Current and Eleven Point Rivers in Missouri.

Habits.—The Hellbender is entirely aquatic in its habits and is frequently caught by fishermen on hooks baited with minnows. I never have seen one from the Mississippi near St. Louis, and I hardly think they will be found, as the river is too muddy and the water too warm in summer. The animal seems to like clear, cold water. Boiling Spring, near Arlington, Phelps Co., Mo., is an ideal place for them, where they can be easily secured with a hook baited with minnows or worms.

Superfamily Salamandroideae.

The Salamandroids fall into three families, namely, the Ambystomidae, Plethodontidae, and Salamandridae. The Plethodontidae are characterized by the presence of parasphenoid teeth.

Family Ambystomidae.

No branchial tufts; openings closed in adults. With four legs; fingers four, toes five. Palatine teeth in a more or less transverse series. Eyelids present. Teeth on the maxillaries and premaxillaries. No parasphenoid teeth. Tongue free in front. Palatine bones not prolonged over the parasphenoid. Pterygoids and prefrontals present, the latter with the parietals prolonged and embracing the frontals. Occipital condyles sessile. Carpus and tarsus ossified. Vertebrae amphicoelian. (Garman.)

Genus AMBYSTOMA.

Palatine teeth in a transverse, often interrupted row, sometimes in the form of an arch or crotchet. Toes, four in front, five behind, never palmate. Tongue fleshy, round or long, centrally attached, with lateral and anterior margins free. Skin smooth, slimy, perforated with mucous pores, especially above the orbits and in the parotid region, costal furrows strongly marked. Tail rather long, compressed distally, with no membranous expansion. Gular fold present. Palms and soles generally with one or more tubercles.

Synopsis of Missouri Species.

Palatine series of teeth not extending outside the inner nares. Plicae of tongue radiating from a median longitudinal groove. Mandible projecting. Color blackish or brownish, with gray spots on the sides. A rather slender species. *microstomum.*

Palatine series of teeth extending outside the inner nares. Tongue with no longitudinal grooves, plicae radiating from behind. Costal grooves twelve. Two distinct plantar tubercles. Color brown or black, with numerous yellow spots; these generally aggregate on the sides of the belly. *tigrinum.*

Costal grooves eleven. A series of round yellow whitish spots on each side. Spotless below. *punctatum.*

Costal grooves eleven. Transverse gray bands on the back. A rather stout species. *opacum.*

5. Ambystoma microstomum Cope. Small-mouthed Salamander.

Amblystoma porphyriticum, Amblystoma microstomum, Chondrotus microstomus.

Description.—Palatine teeth forming a slightly angular series, with convexity forward entirely between the internal nares (choanae). Tongue not very large, oval, with a median longitudinal groove from which the plicae radiate. Head very small, very convex, slightly longer than broad. Snout very short, broad, rounded, without canthus rostralis. Lower jaw projecting a little beyond the border of the upper. Eyes moderate. Body cylindrical, much elongated, four and a half times the distance from snout to gular fold. Limbs short, widely separated when laid against the body; fingers and toes moderate, cylindrical, depressed. Carpal and tarsal tubercles indistinct. Tail as long as the head and body, or a little shorter, subcylindrical at the base, becoming strongly compressed at the end, which is obtuse. Skin shining, minutely pitted. No parotoids. A strong gular fold. Fourteen costal grooves, extending nearly across the body, leaving the middle of the back smooth.

Color.—Brownish grey or blackish, paler beneath, with numerous grayish white spots on the sides and sometimes also on the belly. Some with lichen-like spots on the sides.

Size.—Total length 170 mm.; from tip of snout to posterior end of anal slit 82 mm.; tail beyond the latter point 88 mm.

This species bears a close resemblance to *Plethodon glutinosus*, from which the generic peculiarities, the longer digits, etc., readily distinguish it. The bluish spots too are much less sharply defined and duller, less silvery, and do not occur on the back in nearly as great numbers as in *P. glutinosus*. From *A. jeffersonianum* it can readily be distinguished by the projecting lower jaw; much smaller and more arched head, greater number of costal furrows, more evident spots on the sides, etc., beside the important peculiarities of tongue and teeth. (Cope.)

Habitat.—This species is recorded from Ohio to South Carolina, west to eastern Kansas and Louisiana. It has also been brought from Hudson Bay. In Missouri it is sometimes very common in suitable localities. I can record it from the following counties:—St. Louis, Jefferson, Butler, St. Charles, Stoddard, and Montgomery, in Missouri, and St. Clair in Illinois.

Habits.—The Small-mouthed Salamander spends the winter months in and about stagnant pools and sloughs. In February it may be seen under the thin ice crusts. March 20th I caught a number of them in a slough under logs, where they seemed to come out of crayfish holes, and tried to escape into them again. They feed on earthworms. O. P. Hay in his report on the Batrachians of Indiana gives a fine life history of this species.

Dates of capture.—March 17, 25; April 8, 15, 28; May 24; October 26.

6. Ambystoma tigrinum Green. Tiger Salamander.

Amblystoma tigrinum, Salamandra tigrina, Salamandra lurida, Triton tigrinus, Triton ingens, Salamandra ingens, Ambystoma ingens, Ambystoma episcopus, Ambystoma maculatum, Ambystoma proserpine, Ambystoma mavortia, Ambystoma mavortium, Ambystoma californiense, Ambystoma fasciatum, Ambystoma nebulosum, Camarataxis maculata, Amblystoma obscurum, Siredon lichenoides, Siredon gracilis, Desmiostoma maculatum, Siredon pisciformis, Siredon tigrinus, Axolotl.

Description.—This species, as now recognized, is one of the most widely distributed of North American Caudata, being known from Maine to Florida, west to California, and southwest to Mexico. In this wide extent of territory the species has been subjected to a great variety of conditions, and the result has been the production of numerous forms, which differ so much that they have been described as distinct species under many names. The discovery of intermediate specimens has resulted in bringing all the forms under the earliest name, *tigrinum*. (Hay.)

The arrangement of the palatine teeth is extremely variable, the series being continuous or slightly interrupted externally or medially, or in a straight line, or at an angle directed forward, or an arch with the convexity forward, with all possible intermediate forms, extending externally to the posterior outer border of the choanae. Tongue large, plicae radiating from behind. Head depressed, as long as broad, greatest width at angle of jaws; snout broad, rounded, without canthus rostralis. Eyes moderate. Body stout, swollen, slightly depressed. Distance from gular fold to posterior end of vent from three to three and a half times the distance from the tip of the snout to the gular fold. Limbs stout, appressed against the body; the median fingers and toes meet or cross. Fingers and toes short, much depressed, pointed. Carpal and tarsal tubercles distinct. Tail longer than, as long as, or shorter than head and body, strongly compressed, keeled posteriorly, ending in a point.

Skin shining, minutely granulated. The parotoid region much swollen, wider than the skull, and about equal to the distance from snout to gular fold. A vertical groove behind the angle of the mouth, crossed by another horizontal groove from the eye to the gular fold, which is very strong and even overlapping. There is a decided constriction at the neck. Twelve costal grooves well marked.

Color.—The colors vary in individuals and with age. The yellow spots may be distinct and bright yellow or so obscure as to be scarcely discernible; they may be abundant and pretty regularly distributed, or may be few in number and confined chiefly to the sides of the belly. Young just from the water are nearly uniformly brownish black above, with no spots or a very few small ones, and are yellowish beneath, with perhaps a few indistinct spots on the sides. (Garman.)

Adult specimens are of a dark, livid black-brown color on the back, olivaceous on the sides, and from light olive to dirty white or yellowish beneath, with the yellow spots distributed as given above. All my specimens from Missouri have no vertical yellow bands on the tail as seen in some specimens in my collection from the Cherokee outlet in Oklahoma.

Size.—The largest adult specimen measures from the end of the snout to the posterior end of the anal slit 130 mm.; from there to the end of the tail 135 mm.; total length 265 mm. An adult, but very small specimen, from Montgomery Co., Mo., has a total length of 97

mm., 55 mm. from the tip of the snout to the posterior end of the anal slit, and 42 mm. from the last point to the end of the tail. A larva from Adair Co., Mo., has a total length of 142 mm., 72 mm. in front of anal slit and 70 mm. to end of tail. Color light yellowish grey above, sides and belly yellowish. Sides of tail marbled with dusky spots. The fin on top of the back begins nearly behind the head and runs over the upper part of the tail to the end. Three branchial tufts.

Habitat.—As stated above this salamander is distributed over nearly the whole United States and a part of Mexico. I can report specimens from the following counties in Missouri:—Adair, Buchanan, Butler, Gasconade, Montgomery, Pike, St. Charles, and St. Louis; and from St. Clair, Monroe and Madison counties, Ill., neighboring counties across the Mississippi River.

Habits.—The animal is nocturnal in its habits and is of rather common occurrence in the city of St. Louis, where it is often found in cellars and new building excavations. In Spring the stagnant waters are full of larvae. In the country they are often plowed up in the fields. The farmers call them ground puppies. Their food consists of all kinds of insects and worms. To my great dissatisfaction they even swallowed other smaller salamanders and little frogs that were imprisoned with them in my collecting bucket.

Dates of capture.—April 4, May 16, 26.

7. Ambystoma punctatum Linn. Spotted Salamander.

Lacerta carolinae, Lacerta punctata, Lacerta maculata, Salamandra punctata, Lacerta subviolacea, Salamandra subviolacea, Salamandra venosa Amblystoma carolinae, Amblystoma argus, Amblystoma punctatum, Amblystoma subviolaceum.

Description.—A species with a broad head, stout body, black groundcolor, and yellow spots. Palatine teeth in three series, the median one generally in a straight line or a double arch, the convexity of which is turned backward, sometimes forming a single arch. Lateral series a little in advance of the central and not quite half its length, separated from the central one by a slight interval. The three teeth patches slightly behind the choanae. The latter openings considerably farther apart than the external nostrils. Mouth large. Tongue moderately large, plicae radiating from behind.

Head depressed, a little longer than broad, the greatest width at the angle of the jaws. Snout broad, rounded. Eyes moderate. The gular fold rises high on the side of the neck. A slight vertical fold behind the angle of the jaws and a horizontal one running back from the jaws to the gular fold. Body plump. Eleven costal furrows. Specimens preserved in strong alcohol show a dorsal groove, which cannot be seen in the living specimens. Distance from snout to axilla in distance from snout to groin 2.5 times. Limbs moderately developed; when appressed along the sides, the fingers and toes meet in the male and remain separated generally in the female. Toes rather short and depressed. Carpal and tarsal tubercles generally indistinct. Tail thick at the base, becoming compressed toward the end. A well-marked depression along each side of the tail, which is usually shorter than the head and the body. Skin smooth, but well supplied with pores. A row of enlarged pores along the upper jaw, another inside the orbit, and one on each side of the upper edge of the lateral groove of the tail.

Color.—The color varies in live specimens from slate-blue to deep black; in alcoholic specimens a dark liver brown above, abruptly olivaceous beneath. On each side of the back is a series of nearly circular spots, about the size of the orbit, usually three on each side of the head, eight or nine on the body, and as many on the tail, where they are sometimes confluent. These spots are white in alcoholic specimens, but orange yellow in life. Along the sides and the upper parts of the legs are scattered some quite small whitish spots. (Cope.)

The animal, when alive, is perfectly smooth and lustrous, and readily exudes a large quantity of a white milky juice from the upper side of the head, body, and tail. This is due to the presence of glands closely implanted in the skin, the pores of which are sometimes quite conspicuous. On the tail they are much the largest and deepest, and the lateral groove marks their inferior boundary, the glands being implanted vertically. (Cope.)

Size.—Largest specimen from snout to posterior end of vent 88 mm.; from vent to end of tail 62 mm.; total length 150 mm.

Habitat.—It is distributed from Halifax, N. S., to Wisconsin and south to Georgia and Texas. Missouri localities:—Butler, Crawford, Jackson, Johnson, Oregon, Shannon, Stoddard, Stone, and St. Louis counties.

Habits.—Like its kindred, this species resorts in early spring to stagnant ponds for the purpose of depositing its spawn. As early as March 6th I found them in low marshy places under rotten logs, which were partly lying in the water. April 16th I captured some in a cypress

swamp near Poplar Bluff, Butler Co. It was a very dark afternoon, just before a heavy thunderstorm, when the yellow spots appeared in the dark as if phosphorescent. Their food consists of earthworms, which they devour with great greediness. The worms are swallowed by a succession of gulps. Prof. S. W. Garman as well as Dr. O. P. Hay observed that the tail is prehensile and used to keep the animal from falling. This species, like the two preceding, *A. microstomum* and *A. tigrinum,* when under water draws this in through the nostrils and at intervals expels it by the mouth, which enables it to remain for a considerable time under the water.

Dates of capture.—March 6; Apr. 16, 24; July 17; Oct. 26.

8. Ambystoma opacum Gravenhorst. Marbled Salamander.

Salamandra opaca, Salamandra fasciata, Amblystoma opaca, Amblystoma fasciatum, Amblystoma opacum.

Description.—This species has a short, stout, swollen body, short tail, and weak limbs. Color dark with light colored cross bands. Head rather broad, depressed, its greatest width about three-fourths of the length from snout to gular fold. The gular fold is interrupted at the nape with a constriction behind the angle of the mouth and a lateral groove connecting the two as in *A. punctatum.* Tongue extensively free at the sides, with the plicae radiating from behind. The vomero-palatine teeth consist of two lateral and a median series, the interruptions occurring just behind the choanae. Eyes moderate, pupils circular. The neck is distinct. Distance from the snout to the gular fold not quite 3.75 times in that to insertion of hind legs.

Body nearly cylindrical but decidedly depressed. No dorsal furrow. Eleven well-marked costal grooves, three on the pelvic portion, and some on the base of the tail, becoming fainter towards the end. Tail oval in section, short and stout. The lateral groove is very indistinct. Measured from behind the vent it is 1.6 times the length of the head and body. The digits are linear, depressed, without any web. The third finger and the fourth toe are the longest. The plantar tubercles are distinct. The skin is everywhere pitted with minute pores.

Color.—Dark brown or black. Across the back and upper side of the tail is a series of light gray or silvery transverse bands, which

widen at each end into an inverted V on the back, but are more linear on the tail. These bands number about seven on the body and as many on the tail, occasionally more or less; sometimes they are confluent with those before and behind, but often are interrupted in the middle. They do not descend more than one-third on the sides, being confined to the dorsal region. There is also a similar patch on top of the snout. Limbs and belly may be uniform in color, or may be sprinkled with white dots.

Size.—Largest specimen, 71 mm. head and body, 44 mm. from posterior end of vent to end of tail; total length 115 mm.

Habitat.—From Long Island and Florida, west to Wisconsin, south to Louisiana. In Missouri I can record it from Butler, Dunklin, New Madrid, Oregon, Pemiscot, Stoddard, and St. Louis counties, and from Monroe and Randolph counties in Illinois.

Habits.—The habits of this salamander have been most carefully studied by Col. Nicholas Pike, with specimens collected on Long Island. He states in Bulletin No. 7, page 209, of the American Museum of Natural History in New York, that eggs and young were taken soon after the ice had left the ponds toward the latter part of March. The eggs were enveloped in a glairy mass. The young emerged in fifteen days. At first they were of a dingy brown color, with two rows of pale dots along the sides. When a month old, they were excessively active. Some which were dissected had in their stomachs the larvae of insects, etc. At the age of two months, they would eat small mollusks. When an inch long the gills are fringed, the tail-fin is edged with black, the rows of white spots are more prominent, and the head broader and more prominent also. The gills appear to be absorbed, and the fin membrane to disappear, when the length is about two inches, the whole body being sprinkled with white dots. As soon as the branchiae are absorbed, the larvæ become restless, seek to escape from the water, and if confined in it, many of them die. If permitted they crawl into moss and leaves, and curl up there in contentment. The metamorphosis occurs about the 5th of May. It is, however,

not until the last of July that they assume the colors of the adult. From the time when the eggs are laid until the young have taken the complete adult form and color about four and a half months elapse. The animal is then two and a half inches long.

Colonel Pike regards *A. opacum* as strictly terrestrial, entering the water only for the purpose of depositing its eggs. They will eat almost any animal substance that they can swallow. The Colonel also states that this species hibernates late, hiding under leaves and burrowing in the ground. He says it has been known to burrow in soft ground to the depth of three feet. (Hay.)

Dates of capture.—Apr. 6, 16; May 3; Sept. 5; Oct. 24; Nov. 13.

Family Plethodontidae.

No branchial tufts; openings closed in adults. With four legs, four fingers, toes four or five. Palatine series of teeth more or less transverse. Teeth on the maxillaries and premaxillaries. Parasphenoid teeth present. The tongue attached by a slender median pedicle and free all around, or attached by a median strip which extends from the anterior margin to about the middle, the tongue being thus free at the sides and behind. Palatines not prolonged over the parasphenoid. Pterygoids wanting. Prefrontals present, not prolonged and embracing frontals. Premaxillaries generally embracing a fontanel. Occipital condyles sessile. Carpus and tarsus cartilaginous. Vertebrae amphicœlian. Eye-lids present. (Garman.)

Synopsis of Missouri Genera.

Tongue attached by a median strip, and free at the sides and behind. Two premaxillary bones. Fingers four. Toes four. Parietals ossified. *Hemidactylium.*
Fingers four. Toes five. Parietals ossified. *Plethodon.*
Tongue attached by a pedicle and free all around. One premaxillary bone, with a fontanel. Fingers four. Toes five, free. Cranial bones ossified. *Spelerpes.*

Genus hemidactylium.

Fingers four, toes four. Tongue attached by a median strip, free laterally and posteriorly. Palatine teeth interrupted medially. Parasphenoid patches not in contact. Parietals ossified, without fontanel. (Garman.)

9. Hemidactylium scutatum Schlegel. Four-toed Salamander. Scaly Salamander.

Salamandra scutata, Salamandra melanosticta, Desmodactylus melanostictus, Desmodactylus scutatus, Batrachoseps scutatus.

Description.—Whole skin finely granulated. Head flattened above, broadest just behind the eyes. Snout short, truncate. Width of head in length to groin about six times. Gular fold rising above nearly to middle line. Vomero-palatine teeth in two short series just behind the choanae. The parasphenoidal patches not in contact. Eyes not large nor prominent.

Body cylindrical. A dorsal furrow runs forward to the vertex of the head, where it bifurcates, sending a branch to each eye. Fourteen costal grooves, which are more or less indicated across the belly. On each side of the back is a faint longitudinal groove; above this, the costal furrows run forward and meet in the middle line in an acute angle. Base of tail with a decided constriction, beyond which the tail again swells out and then tapers to a point. Both upper and lower edges of tail with an evident ridge for the greater part of the length. Limbs feebly developed. Fingers and toes almost rudimentary.

Color.—Back, dark chestnut. Snout above, eyes above, and, in certain lights the furrows above the lateral lines, light chestnut, approaching to golden bronze. Pupils large, black. Iris above golden bronze. Head, body, and tail below chalk white, with a tinge of blue, sparingly and irregularly marked with rather large black spots; spots disposed along the sides and the white of the tail beneath. Central tract unspotted. (Cope.)

Size.—From end of snout to vent 33 mm., tail 21 mm. Total length 54 mm.

Habitat.—This species is distributed from Massachusetts and Canada westward as far as Missouri and Arkansas, south to Georgia. It is regarded as rare, although it appears to be abundant in places. My friend, Dr. George W. Bock, found one—the only Missouri specimen I have—at Bourbon, Crawford Co., Mo. He found it on a gently sloping hillside, where a little creek flows at times, under a rock on the side of the creek bed. The writer found two under a rock in a little valley near Hot Springs, Ark.

Habits.—Kennicott reports this species common in some localities in northern Illinois. He found it under

logs, and says it is very quick in its movements. O. P. Hay in his report on the Batrachians and Reptiles of Indiana, says: "When this species has been dropped on its back, it will often lie for a time perfectly quiet, as if feigning death. I have heard it give a faint squeak like the scratching of a quill toothpick against paper. It can readily climb a perpendicular surface, and it can suspend itself by its tail. When thrown into water, it may hide for a while at the bottom, but it soon endeavors to get out." The food is said to consist principally of worms and insects.

Genus PLETHODON.

Vomero-palatine teeth in two more or less oblique series which lie behind the choanae. Parasphenoidal teeth present. Premaxillaries separated. Digits 4-5. Tongue free laterally, but attached medially in front. (Hay.)

Key to Missouri Species of Plethodon.

Costal grooves 16 to 19. Color above dark brown with a red dorsal stripe. *erythronotus.*

Costal grooves 14. Color above bluish black, with small white dots. *glutinosus.*

10. Plethodon erythronotus Green. Red-backed Salamander.

Salamandra erythronota, Amblystoma erythronotum, Salamandra agilis, Plethodon cinereus var. erythronotus, Plethodon erythronotus var. erythronota, Plethodon cinereus.

Description.—This species is among the most elongated and slender American salamanders. Head small, flat above, depressed. Mouth large, the upper jaw slightly projecting over the lower one. Tongue large, attached by a strip along the middle, slightly free behind. Vomero-palatine teeth in two short, arched, backwardly converging rows, which do not extend beyond the choanae. Parasphenoid teeth in two patches lying close together. Eyes prominent. Gular fold distinct, rising high on the sides of the neck, a distinct groove running back from the corner of the eye to the gular fold, where it is met by a vertical groove from the corner of the mouth. Neck distinct. 16 to 19 costal grooves. Limbs short and weak. Digits short, the inner ones rudimentary. Tail round, pointed, equal to or longer than the head and body.

Color.—A broad, light reddish stripe commences at the nape and continues to the tip of the tail, where it diminishes gradually in width. The central region of this stripe generally exhibits a fine mottling of brownish, scarcely obscuring the effect of the red ground color. The sides of the body are abruptly and continuously dark brown, which soon fades into the pepper and salt of the lower sides and belly. The color of the red stripe varies considerably and turns yellow in alcohol.

Size.—Length from end of snout to posterior end of vent 50 mm., tail from vent 50 mm. Total length 100 mm.

Habitat.—Cope states in his Batrachia of North America, on page 134, "This species is found throughout the United States east of the Mississippi River. It appears to be more abundant in the Middle States; its northern range is to the middle of Maine, Ontario, and Michigan." I was, therefore, very much astonished when my late friend, Mr. Colton Russell, brought me a fine specimen from Crève Coeur Lake, St. Louis Co. This was the first report of the species west of the Mississippi River. Mr. Russell presented me afterward with specimens which he had collected in Jefferson and Madison counties, Missouri. I have never yet found an Ashy Salamander, *Plethodon cinereus,* west of the Mississippi. So far I have found *P. erythronotus* in the eastern hilly part of Missouri, from the Missouri River south to Farmington, St. François Co. When once a locality has been discovered, they are generally found to be quite abundant.

W. H. Smith in his Tailed Amphibians states on page 65 "It is found in moist woody places, hiding under stones and old logs, and when discovered if alone, it quickly disappears in the decayed wood moss or earth, but if accompanied by its young neither it nor the little ones attempt to escape. It climbs glass by adhering with its abdomen, is frequently curled up on herbs, and if disturbed springs away by a sudden uncoiling. Their food appears to be small snails and mollusks. When young they are found as a rule accompanied by the parents. The little ones as well as their eggs occur under the moss and bark of decayed trees. The eggs are found in bunches of from

six to eleven each, and individually are about 3 mm. in diameter. The young are supplied with branchiae but lose them very early—that is about three or four days after hatching."

Dates of capture.—Feb. 12; Mar. 7, 21; Apr. 4, 8, 23; May 7; Sept. 21.

11. PLETHODON GLUTINOSUS Green. Slimy Salamander.

Salamandra variolata, Salamandra glutinosa, Salamandra cylindracea, Plethodon variolosum, Triton porphyriticus, Plethodon glutinosum, Cylindrosoma glutinosum.

Description.—Head moderate, width in the distance to the groin six times. Snout rounded. The upper jaw projecting beyond the lower. Tongue large, the posterior fourth and sides free, the plicae radiating from behind. Vomero-palatine teeth in two short, separated, anteriorly convex arches, which laterally pass a little beyond the choanae. Parasphenoidal bands in close contact throughout and anteriorly removed from the vomero-palatines. Choanae as widely separated as the external nostrils. Gular fold not overlapping, met by a groove from the eye. Eyes rather large and protruding.

The body, rather heavy for the genus, is cylindrical or somewhat depressed. Skin smooth and shining, pitted with numerous minute pores, which secrete a white sticky fluid. Length from the end of snout to axilla in the distance from end of snout to groin 2.75 times. Costal grooves 14. Limbs moderately developed. Digits short and depressed; the inner on fore and hind legs are small, but distinct. Tail equal to or longer than the head and body, cylindrical in section, and tapering to a point.

Color.—The color above is bluish black, sometimes nearly black. Along the sides are numerous whitish blotches, about the size of the eye. Sometimes these are more or less confluent. On the back and top of head the spots are usually smaller and not as bright. Under surface of head and neck paler. The gular fold, as well as the carpal and tarsal surfaces, and toes are whitish. The edges of the two jaws are also of that color. Belly bluish with minute dots of white, which are not always the mouths of mucous pores, and are not always present. Vent bordered with white. (Hay.)

Size.—Largest specimen from end of snout to vent 71 mm.; from vent to end of tail 67 mm. Total length 138 mm.

Habitat.—This species is distributed from Maine to Wisconsin and south to Texas and Alabama. Missouri localities:—Crawford, St. Francois, St. Louis, St. Charles, Jefferson, Phelps, Montgomery, Stone, and Madison coun-

ties. In Illinois, St. Clair, Madison, and Randolph counties.

Habits.—This species resembles the variety *laterale* of *Ambystoma jeffersonianum,* and to a less extent *Ambystoma microstomum,* but is distinguished from both by the possession of parasphenoidal teeth. Like *Plethodon erythronotus* this species appears to be wholly terrestrial. It is found hiding in shady, cool places, where it haunts rocky localities under logs and stones, whence at night it comes to seek its prey. The food consists of insects and other small animals that may fall within its reach. It is especially remarkable for the development of prehensile powers in its tail. It will wrap its tail around one's finger and hang there for quite a while. It is one of the most common species of Salamanders in Missouri.

Genus SPELERPES.

Vomero-palatine teeth in two series, which either converge backward without reaching the parasphenoids, or run transversely to the anteriorly prolonged parasphenoidal patches. These patches are either separated or joined along the middle line. Tongue small, supported on a central stalk, mushroom-like. Premaxillaries ankylosed, their spines enclosing a fontanelle. Limbs moderately well developed. Digits 4-5. (Hay.)

Key to the Missouri Species of Spelerpes.

13 to 14 costal grooves. Body slender. Vomero-palatine teeth not meeting the parasphenoidal patches.
- Tail considerably longer than the head and body.
  - Yellow, with black spots; tail with black cross-bars. *longicaudus.*
  - Orange red, with black spots on body and tail. *maculicaudus.*
  - Back raw sienna in color. Median line and a streak on each side of the back, a line from the eye back to above the hind limb, and the top of the tail free from spots. *stejnegeri.*
  - Yellow, with a broad dorsal band and another on each side of back. *guttolineatus.*
- Tail not much longer than the rest of the animal. The sides of the head, body and tail black, belly white in life. *melanopleurus.*

21 costal furrows; color dark. *multiplicatus.*

12. SPELERPES LONGICAUDUS Green. Long-tailed Salamander. Cave Salamander.

Salamandra longicauda, Salamandra longicaudata, Spelerpes lucifuga. Cylindrosoma longicauda, Saurocercus longicauda, Spelerpes longicauda.

Description.—Head of moderate size, slightly wider than the neck, depressed. Eyes prominent. Gape large. Jaws week, margin of upper lip angulate on each side and slightly excavated between the angulations. Tongue attached by a distinct pedicle. The palatine teeth form a short arch, which begins behind and on a line with the inner border of the choanae, and curves inward and backward for a short distance. The parasphenoid teeth begin a short distance behind the palatine teeth, with a decided interval, however, and form two patches in contact along the median line. Gular fold distinct, arched, with the convexity forward. A slight groove from the eye to the fold.

Body very slender, with 13 costal furrows. The limbs are well developed; the digits lengthened, cylindrical, depressed, and slightly swollen into bulbs at the ends. The third and fourth toes are the longest, the second and fifth nearly equal. The first finger and toe very short but not rudimentary. Tail extremely long, about 1.5 times longer than the head and body, compressed vertically to an attenuated tip. Skin smooth and shining.

Color.—The ground color is of a clear bright yellow, paler beneath, the back and sides irregularly sprinkled with black dots. These are generally (but not always) more thickly crowded along the sides, sometimes almost forming a distinct band. On the sides of the tail are vertical black bands. The muzzle and entire under-parts are immaculate. The shade of yellow varies sometimes to reddish. Legs spotted with black above, uniformly pale or with a few spots below. (Cope.)

Size.—50 mm. from tip of snout to vent, 80 mm. from vent to end of tail. Total length 130 mm.

Habitat.—This species ranges from Maine and Wisconsin south to Louisiana and Florida. Missouri localities: St. Louis, Jefferson, Crawford, Miller, Ozark, and Washington counties. Illinois, St. Clair county.

Habits.—This salamander is generally common where found. It occurs on the sides of cold water creeks under flat stones at the entrances to caves, where they are found under rocks partly in water. In Green's Cave, near Sullivan, Crawford Co., Mo., I found one under a large slab, nearly 300 feet from the entrance of the cave where no

daylight could penetrate. They resemble lizards in the quickness of movement when attempting to escape. I am not acquainted with their feeding or breeding habits.

Dates of capture.—Mar. 22; Apr. 8, 12, 19; May 1, 6, 10; July 28; Sept. 1.

13. SPELERPES MACULICAUDUS Cope. Spotted-tail Salamander. Hoosier Salamander.

Gyrinophilus maculicaudus.

Description.—This species resembles somewhat *S. longicaudus*, but differs in form, arrangement of vomero-palatine teeth, and color. Head broader and flatter than in *longicaudus*, contained in distance to groin 5 to 5.5 times. The distance from snout to axilla in distance to groin 3.5 times against 4 times in *longicaudus*. The series of vomero-palatine teeth runs forward to a point in advance of the hinder border of the choanae, or even to its anterior border, and then turns abruptly outward and backward, so as to produce the form of a hook. Costal grooves 13 or 14. Snout truncate. A distinct gular fold. Eyes prominent. Tail long and compressed, containing head and body 1.5 times. (Hay.)

Color.—The ground color varies from orange to vermillion red. The head and body are irregularly spotted with black dots about the size of the pupil, or larger. The tail and the upper surface of the legs are similarly spotted. The lower surface is uniform yellowish. In many specimens there is on each dorso-lateral region a row of black spots, which begins over the arm and runs back on the tail. In the middle of the back there is an irregular row of spots.

Size.—From tip of snout to vent 65 mm.; from vent to end of tail 88 mm.; total length 153 mm.

Habitat.—This species is confined to the Mississippi Valley. It has been collected in Tennessee, West Virginia, Kentucky, Indiana, Illinois, and Missouri. In Missouri it has been taken in Rockhouse Cave, Barry Co., Wilson's Cave, near Sarcoxie, Jasper Co., Marble Cave, Stone Co., Fisher's Cave, near Sullivan, and Onondago Cave, near Leasburg, both in Crawford Co. Away from caves it has been found near Pevely, Jefferson Co., and in St. Louis Co. In Illinois it has been captured in a cave near Burksville, Monroe Co.

Habits.—This salamander is commonly found in caves, and, as a rule, not far from the entrance, usually barely beyond twilight. Banta and McAtee state that sometimes it ventures into deeper recesses, being reported from a spot one and a half miles within Wyandotte Cave. It resorts regularly to such places to lay its eggs, as larvae have been found in the remoter portions of Wyandotte, Mayfield, and Mammoth Caves. The writer found this salamander plentiful near Pevely, Jefferson Co., near springs originating in the limestone formation, but there is no cave in the whole neighborhood. They are generally found under slabs on the sides of gullies, which indicates that they are more or less independent of caves. Near Marble Cave I found in two small caves a lot of *maculicaudus* and *stejnegeri* together. They are generally found clinging to the walls of the cave. In the cave near Burksville, Monroe Co., Ill., I caught with a dip net an adult and three larvae May 11, 1903, far away from the mouth of the cave, which was at the bottom of a sink-hole. The whole cave, through which a little creek ran, seemed to be just a drain of quite a number of such sink-holes. For the breeding habits and the development I may refer the reader to the life history of this salamander by Banta and McAtee in the Proceedings of the U. S. National Museum, Vol. 30. This species was originally described from a specimen sent to Professor Cope from Brookville, Indiana.

Dates of capture.—Apr. 15, Nov. 30.

14. Spelerpes stejnegeri Eigenmann. Stejneger's Cave Salamander.

Description.—Head a little wider than neck. Snout nearly truncate. Eyes prominent. Tongue attached by a pedicle. Vomerine teeth arranged in the shape of a V with the anterior limbs ending behind the internal nares. A gular fold turning well up on the sides of the neck. A groove from the eye to the gular fold. Costal grooves 13.

Body slender. Fingers and toes do not meet on the sides by a space equal to at least the width of an intercostal space. In small specimens this space is less, and the legs may even meet. Feet and toes well

developed. Tail more compressed than in *S. maculicaudus*. Length of tail 1.9 times longer than head and body.

Color.—*Spelerpes stejnegeri* differs from both *S. maculicaudus* and *S. longicaudus* in color. The back in *S. stejnegeri* is raw sienna with many dark spots, coalescing in places and irregularly arranged in two series on either side of the median line. Some specimens have these spots on the side of the back more numerous, forming sometimes nearly a stripe. The median line, and a streak from the eye back to above the hind limbs, as well as the top of the tail, are free from spots or have very few. Sides of the tail with marbling of sienna. Top of feet marbled like the sides. Belly yellowish white, sometimes with a few light dots.

Size.—From end of snout to vent 46 mm.; from vent to end of tail 88 mm. Total length 134 mm.

Habitat.—It is found in the Ozark Plateau, becoming more numerous toward the south. Missouri localities:—Rockhouse Cave, Barry Co., Wilson's Cave, near Sarcoxie, Jasper Co., Fisher's Cave, near Springfield, Greene Co., Green's Cave, near Sullivan, Franklin Co., near Marble Cave, Stone Co., Pineville, McDonald Co., Jerome, Phelps Co., and Leasburg, Crawford Co.

Habits.—This species is also a twilight species, as it is mostly found under slabs of rock at the mouth of caves and never a very great distance into the cave. At Wilson's Cave—a small cave—I found this salamander among the rocks which dam the little creek at the mouth of the cave. When I visited the cave there was no running water but a little pool just inside the cave. I managed to capture a few small larvae. Near the residence of Hon. Thurman S. Powell, near Marble Cave, I found a good many of these salamanders in holes under rocks at the bottom and sides of the caves, where they were clinging to the rocks. At Green's Cave, Franklin Co., which has a large portal-like entrance, I caught some of them under rocks in the water, but not further back in the cave than daylight penetrated. Those from Jerome and from near the Onondago Cave were caught under rocks on the shady side of the ravines. Those at Pineville I fished out of a little spring on the side of a hill in an open pasture. I do

not know anything of the food habits of the salamander, which, in all probability, will be similar to those of other *Spelerpes.*

15. SPELERPES GUTTOLINEATUS Holbrook. Holbrook's Salamander.

Salamandra guttolineata. Cylindrosoma guttolineatum.

Description.—This species in its general proportions and shape is very similar to *S. longicaudus.* It appears to be rather stouter, and the head a little broader. The eyes are larger, the toes shorter. The protuberances of the upper lip are rather larger, which gives a more emarginated outline to the jaw when viewed from the front. Sphenoidal and vomerine teeth not contiguous. Costal grooves 13. A light gular fold. (Cope.)

Color.—Yellowish above; back with three black longitudinal bands as wide as the spaces between them. The two outer bands begin at the eye and extend along the side of the tail, marked with a few light dots. A spot between each two costal grooves. Grayish beneath, clouded with darker gray.

Habitat.—North and South Carolina, Georgia, Alabama, Mississippi, and Missouri. Most abundant in the Alleghany Mountains. So far I have never found this salamander on my collecting trips in Missouri. I introduce it in this list on the strength of specimens collected by Mr. Robert Kennicott in New Madrid Co., which are preserved in the Smithsonian Collection. (No. 3733. 4 larvae.) My sons, when collecting at Rodney, Jefferson Co., Mississippi, on July 16, 1889, caught a number of them which are now in my collection.

16. SPELERPES MELANOPLEURUS Cope.

Description.—This species resembles *S. bilineatus* Greene, but differs in both proportions and coloration, and is also smaller, being the smallest species of the genus. Although it is smaller than *S. bilineatus,* it is more robust and less sepsiform. The width of the head enters the length to the groins 4.5 times (nearly 6 times in *S. bilineatus*), and the length to the axilla enters the same 2.3 to 2.5 times (2.7 times in *S. bilineatus*). The limbs and all the toes are well developed, the anterior and posterior meet when placed along side of the body; they are separated by three full intercostal spaces in

S. bilineatus. There are always only 13 costal grooves (14 in *S. bilineatus*). Tail strongly compressed.

Color.—The sides of the head, body and tail are black, sparsely spotted with white dots. The upper portion of the band is darkest, representing the dorsolateral line of *S. bilineatus.* A few black spots along the median dorsal line. End of muzzle and chin black. Limbs closely reticulated with black. Belly white in life (yellow in *S. bilineatus*). The white belly in life constitutes a conspicuous color characteristic.

Size.—Largest specimen. Length to angle of lower jaw 4.5 mm.; to axilla 10 mm.; to groin 23 mm.; to end of tail 57.5 mm.; of fore-limbs 6.5 mm.; and of hind limbs 8 mm.

Habitat.—Dr. Cope found five specimens among the rocks on the banks of Raley's Creek, one of the tributaries of the White River. Having never found nor seen one of this species, I copied the whole article as Cope gives it under the title "On a Collection of Batrachia and Reptilia from Southwest Missouri," published in 1893 in the Proceedings of the Academy of Natural Sciences of Philadelphia.

17. SPELERPES MULTIPLICATUS Cope. Many-ribbed Salamander.

Description.—The vomerine teeth form two short series, each rather suddenly bent outward behind the choanae. The two pterygoid patches are separated in the middle, and not approaching the vomerine teeth. Head flat, snout rather thick and short, upper lips moderately truncate. Fingers and toes free and short, especially the inner and outer. Costal grooves twenty-one. Tail a little compressed and considerably thickened and keeled towards the end.

Color.—Above light brown in life, with a darker brown dorsal streak, which starts between the eyes and stops opposite the vent; a short dark streak starts behind the eye over the cheek and fades away near the axillae into a lighter brown lateral streak, which extends sometimes on the sides of the tail to nearly its end. Occasionally a few whitish spots on the sides between the lateral and dorsal lines. The under surface is of a light yellowish to whitish color.

Size.—From end of snout to vent 40 mm.; length of tail 50 mm. Total length 90 mm.

Habitat.—Arkansas, Missouri, and Kansas.

Habits.—I became acquainted with this salamander at Granite Mountain, near Little Rock, Ark., where Mr. J. R. Fordyce and I collected quite a number from under rocks lying in the water and at the edge of a small brook emerging from a spring. A few weeks ago my friend, Mr. Lee Earll, sent me a specimen which he had captured near Marble Cave, Mo. This is the first specimen I have obtained from the State.

Family Desmognathidae.

Palatine teeth borne on transverse processes of the palatine bones. Parasphenoid with two thin plates, bearing elongate patches of teeth. Parietals not embracing frontals. Prefrontals and pterygoids wanting. Occipital condyles with pedicles. Carpus and tarsus cartilaginous. Vertebrae opisthocoelian. Peculiar to America.[3]

Genus typhlotriton.

Vertebrae opisthocoelous; parasphenoid and vomerine teeth. Eyes concealed under the continuous skin of the head; tongue attached in front and along the median line, free laterally and posteriorly; maxillar and mandibular teeth small and numerous; vomerine teeth in two strongly curved series; parasphenoid patches separate; nostrils very small; toes five. (Stejneger.)

18. Typhlotriton spelaeus Stejneger. Veil-eyed or Blind Salamander.

Description.—Sixteen costal grooves; tail slightly compressed, not finned; toes nearly half-webbed; vomerine teeth in two V-shaped series,

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[3] The families of Plethodontidae and Desmognathidae are founded on internal characters, and require some dissections. These, however, are not difficult to make. By making a short incision along the back of the specimen in hand, dressing away the muscular tissue down to the vertebral column, and then sharply bending the back so that two of the vertebrae separate, it may be seen whether the anterior rounded head of the vertebrae is made of cartilage or bone. If it is of cartilage, the vertebrae are amphicoelous; if of bone, opisthocoelous. In either case, the posterior end of the vertebral centrum is concave. In like manner the wrist and ankle may be dissected and the determination made whether the nodules found in them are composed wholly of cartilage or are bony. Since, however, we have no species where these parts are bony, as in *Thorius* from Mexico, this examination is not necessary. (Hay.)

with the curvatures directed forward; gular fold strong, very concave anteriorly; color uniform pale.

Head wide, much wider than neck, very depressed and flat on top, with no canthus rostralis; snout rather swollen, truncate; nostrils very small; eyes small, only slightly raised, and covered by the continuous skin of the head with only a shallow groove to indicate the opening between the lids, the underlying eyes only visible as two ill-defined dusky spots. Body somewhat depressed, measuring thrice and a third the distance from snout to gular fold; limbs short, about five costal interspaces apart when laid against the body; fingers rather short, especially the first, nearly free; length, beginning with shortest, 1-4-2-3; number of phalanges 1-2-3-2; toes rather short, first almost rudimentary, nearly half-webbed; length, beginning with the shortest, 1-2-5-4-3, second and fifth, and fourth and third being nearly equal; number of phalanges 1-2-3-3-2. Tail considerably shorter than head and body, subcylindrical at base and somewhat squarish, more compressed towards the tip, rounded above, faintly keeled below; skin minutely granulate; gular fold strong, very concave anteriorly and uniting on the sides of the neck with a horizontal groove running from the eye backwards. Sixteen costal grooves, or eighteen, if counting the axillar and groin grooves, crossed on the sides by a strong horizontal groove between axilla and groin.

Maxillar and mandibular teeth small, numerous, normal; vomerine teeth not extending outside of the choanae, forming two V-shaped, strongly curved series with the points directed forward, the external branches straight, the internal ones curved inward and well separated; parasphenoid patches long, rather narrow, well separated, their distance being nearly equal to their width, and well separated from the vomerines; teeth small, in numerous rows. Tongue rather large, attached anteriorly and along the median line for a trifle more than the anterior half, extensively free laterally and posteriorly. (Stejneger.)

Color.—Uniform cream yellow in alcohol; in life pale.

Size.—From snout to vent 60 mm.; from vent to end of tail 60 mm. Total length 120 mm.

Habitat.—Rockhouse Cave, Barry Co., Marble Cave, Stone Co., and Doris Cave, Wright Co., Missouri.

Habits.—The discoverer of this species, F. A. Sampson, of Sedalia, Mo., sent the first specimens—an adult and some larvae—to the Smithsonian Institution. He caught them in July, 1891, in Rockhouse Cave, near Cassville, Barry Co., Mo. He informed Dr. Stejneger, Curator of Reptiles of the National Museum, that the animals were

captured on the rocky walls of the Cave about 600 feet from the entrance. This cave is in places not over two feet wide, in others several times that, and extends into the hill about a quarter of a mile. Although many of our salamanders are known to inhabit caves, this seems to be the only one, which, like some of the other animals living exclusively in caves, has become blind, or nearly so.

In May, 1906, I visited Marble Cave, where Dr. E. D. Cope and Dr. Eigenmann had previously found this salamander. Marble Cave opens at the bottom of a large sink-hole about 50 feet deep, with only a small entrance. Descending a ladder for about 30 feet, we reached the top of a large heap of debris, washed in from the sink-hole. After going down this hill we are in an immense chamber, 200 feet in diameter and about 160 feet high, carved out by the action of water. At a remote corner of this grand hall is a short tunnel. Descending through a deep abyss and under a little waterfall we came to the deepest part of the cave—a veritable mud hole. After a hard climb up this steep muddy clay bank, another horizontal gallery was encountered, where we crawled along on hands and knees. This gallery was comparatively dry, with the exception of a small stream flowing toward the mud hole. Crawling along about 400 feet, we reached a narrow crevice high enough to stand up in. Up to this time we had seen no signs of life, and I had about given up hope of finding this salamander. We now saw in front of us a shelf of rock along which we dragged ourselves. This gallery was very wet, all covered with clay. Here at last we came upon our long coveted prize. After crawling along for another 400 feet, during which time we had collected nine adult specimens, we concluded to turn back. To make better progress we retraced our steps along the stream. We collected eleven more, partly from the sides of the walls, where they were clinging, and from the water. It took us an hour to reach the bottom of the ladder, which would lead us to the surface and to daylight.

I spent several days in the neighborhood, and, while

collecting other reptiles, I found in a small spring nearby a larva of this salamander. This specimen had good clear eyes,[4] not at all covered, but was of the same pale color—even whiter than the adults of the cave. Not knowing anything of the food habits of this salamander and not having detected any other living creature in the cave, I think their food consists of minute organisms, invisible to the eye.

Family Salamandridae.

Salamanders, with the vomero-palatine teeth extending far backward in two parallel or posteriorly diverging series, are characteristic of the palearctic region, especially the Mediterranean subdivision. One genus, *Diemictylus*, extends into North America. (Stejneger.)

Genus diemyctylus.

Tongue small, free at the sides. Palatine teeth in two longitudinal series, which diverge slightly posteriorly. Processes from the frontals and tympanic bones forming an arch behind the orbit. The first and fifth toes rudimentary. Tail strongly compressed. Skin above the eyes and on the jaws with large mucous pores. The following species is the only one which occurs in the Eastern and Middle states. It is the closest ally of the European tritons.

19. Diemyctylus viridescens Rafinesque. Newt, Red-Eft, Spotted Triton, Green Triton.

Diemyctylus miniatus subsp. viridescens, Diemyctylus miniatus miniatus, Triturus viridescens, Triturus miniatus, Salamandra stellio, Salamandra dorsalis, Salamandra symmetrica, Salamandra millepunctata, Salamandra greenii, Triton dorsalis, Triton millepunctatus, Notophthalmus miniatus, Notophthalmus viridescens, Triton punctatissimus, Triton symmetricus, Triton viridescens, Molge viridescens.

Description.—The snout viewed from above is truncate-rounded, and projects a little over the end of the lower jaw. Two ridges on top of the head, enclosing an oblong space on the front of the muzzle and on the occiput. On the external side of these two ridges is a shallow groove. A distinct but obtuse canthus rostralis. The loral region is slightly concave. Eyes rather large. Nostrils in front of the mouth

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[4] Adolf Alt. On the histology of the eye of Typhlotriton spelaeus from Marble Cave, Mo. Trans. Acad. Sci. St. Louis. **19:** 83-96. *pl. xxvi.-xxxiv.* 1910.

look upward and outward. The eyes do not project upward. On the side of the head posterior to the eye is a row of four pits, the first near the eye and the last in the position of the first branchial fissure. The tongue occupies but little space, is slightly free on the sides, but not on the anterior or posterior end.

The vomero-palatine teeth are in two longitudinal series, which converge anteriorly and join between the internal nares. Internal and external nares are about the same distance apart. In applying the legs to the sides of the body, the front limbs overlap the hind ones by the length of the hind toe. In the breeding season the hind legs of the males are thickened, especially the integument of the inner side, which is then divided by transverse folds; the portions between become corneous. There are from 10 to 12 transverse plates on the inner sides of the thighs, and an irregular number on the inside of the tibia and tarsus. The rudimentary external and internal toes also have a horny cap. These horny parts aid the male in maintaining his hold on the female in copulation. The skin is smooth, but closely wrinkled. The tail has a free dermal margin or fin above and below. The genitalia are very prominent during the breeding season, and in the male the orifice is oval and very papillose, especially within the anterior border.

Color.—The color of the "viridescence form" is a light brownish olive above, which is or is not marked off distinctly from the paler color of the lower surfaces along the sides. On each side of the vertebral line is a row of from three to six small, round, red spots, each with a black border. The rest of the surface is marked with small black points, which are smaller but more distinct on the lower surface. The inferior surface is reddish straw color or dirty white. On the legs the spots are larger and more distinct, and on the tail they appear like ink spots on blotting paper. A faint dark line, running from the eye to the last cheek pit, edge of the upper jaw, the chin and throat, generally unspotted.

In the "miniatus form" the tail is narrow, without dermal borders. The color of the superior surfaces is vermillion red, and the lower citron yellow. The red spots are present as in the other form, but the small black spots are rarely present on the back, but always on the sides, belly, limbs, and tail, never, however, running together into lines. In this form the skin of all upper surfaces is rough, with numerous minute, semi-transparent, horny points. (Cope.)

Size.—*D. miniatus* form from snout to vent 53 mm.; from vent to end of tail 50 mm.; total length 103 mm. *D. viridescens* form from snout to vent 41 mm.; from vent to end of tail 50 mm.; total length 91 mm.

Habitat.—The distribution of the species is from Maine to Hudson's Bay, Wisconsin, Texas, and Georgia. In Missouri it has been found in St. Louis, Jefferson, St.

Charles, and Butler Counties, and in Illinois in St. Clair and Monroe Counties.

Habits.—The red form, *D. miniatus,* is so different from the sexually mature, *D. viridescens,* that it was originally described as a distinct species, and even put by Rafinesque in a different subgenus. Cope regarded them as "seasonal forms, which may be by reason of the environment rendered permanent for a longer or shorter time." I secured about twenty specimens of the "miniatus form" in the fall of the year on the side of a bluff from under rocks, logs, leaves, and loose bark of trees. I put them into an aquarium, where some of them took readily to the water, while others tried constantly to climb out. These soon died (about one-third). The remainder adapted themselves to the water, and by the next spring had changed to the mature "viridescens form." They laid eggs, but, unfortunately, these were devoured by some small cat-fish that were in the aquarium. Being away from home for over a month and no one else looking after the aquarium, I found upon my return that my water lizards had changed back to the land form, hiding under rocks and moss outside of the water. For a long time I was only acquainted with the land form of the Red Eft, which I caught in ravines on shady hill sides under rocks and rotten logs. Accidentally I captured in a nearby lake in the spring a number of mature specimens.

Dates of capture.—Apr. 17; May 6; Oct. 3, 15; Nov. 1, 11.

Order SALIENTIA.

Body stout, short, more or less depressed. With two pairs of legs, the anterior of which bear four, and the larger posterior pair five, digits. Mandible toothless. Vertebral column composed of but few vertebrae and terminating in a long solid coccyx—the urostyle. Sternal arch complete. Radius and ulna fused. Tibia and fibula also fused. The two proximal tarsal bones very long and often fused at their extremities.

The adults are tailless and are known as frogs and toads. They move on land by leaps, the structure of the posterior legs being specially suited to this mode of locomotion. The young are known as

pollywogs and tadpoles. These are fish-like, living in water, in which they swim with the aid of a tail, and breathing by means of branchiae. Instead of teeth they possess horny jaws. At this stage of their lives they subsist chiefly on vegetable substances, such as filamentous Algae, diatoms, desmids, etc. (Garman.)

The Salientia may be divided into three suborders, viz., Aglossa, Linguata, and Costata. Of these only the Linguata are represented in Missouri.

Suborder LINGUATA.

Salientia having a tongue; eustachian tubes with two pharyngeal openings; lacking ribs and transverse process to urostyle. Larvae with one spiraculum on left side only. (Stejneger.)

Key to the Families of Salientia.

Clavicles and coracoid of each side connected by an arched cartilage; that of the one side overlapping that of the other. (*Arcifera.*)

Upper jaw without teeth; digits without disks. *Bufonidae.*

Upper jaw furnished with teeth.

Form frog-like, toes and fingers with disks. *Hylidae.*

Form toad-like; digits without disks. *Scaphiopodidae.*

Clavicles and coracoid of the one side firmly connected with those of the other side by means of a narrow median cartilage. (*Firmisternia.*)

Upper jaw with teeth. *Ranidae.*

Upper jaw without teeth. *Engystomatidae.*

Family Bufonidae.

Both upper and lower jaws destitute of teeth. Vomerine teeth usually absent. The diapophysis of the sacral vertebrae more or less expanded. Vertebrae procoelous. Ribs none.

Certain characters are very commonly possessed by the Bufonidae. Among these are a heavy squat form, short limbs, a rough, warty skin, and a collection of integumentary glands lying behind the head, and known as the parotoids. (Hay.)

No vomerine teeth. Tympanum distinct or hidden. Toes webbed; fingers free. Sacral diapophysis more or less dilated. Outer metatarsals united. (Hay.)

Genus BUFO.

20. BUFO LENTIGINOSUS AMERICANUS LeConte. American Toad.

Bufo americanus, Bufo dorsalis, Chilophryne americana, Bufo lentiginosus.

Description.—Head short; snout obtuse; cranium with distinct osseous crests, which are narrow, well marked, and not united in a prefrontal callosity. Frontoparietal ridges divergent, not much produced and well distinguished behind, postorbital ones short, supratympanic wanting or short. Profile of head shows a gradual descent from behind, depressed between prefrontal bones; muzzle slightly decurved, not projecting; nostril a little nearer orbit than labial margin. Eyes large. Tympanum distinct, equal to half the orbit, oval. Head 4 to 4.5 times in length of body. Parotoids quite elongate, varying a little in breadth. Body squat. Legs short and very stout. Fingers a little depressed, with a few small tubercles beneath. First finger projecting nearly at a right angle to the others, and more elongate at the base; the third finger the longest. Palm with a large callosity. Toes depressed, partly webbed, the first the shortest, the fourth the longest.

Skin tuberculate above, granulate below. Vocal sac of male opening by two large slits in the floor of the mouth, one on each side, just within the mandible. As in other Bufones the females are larger than the males and the latter are usually less variegated in color.

Color.—Variable; usually olive or brown, with irregular blotches and spots of dark brown; middle of back with a light streak; below dirty yellow. The upper surface is sometimes almost dark black; at other times brick red, rust color, or ash-gray, showing the dusky spots with great distinctness. Occasionally a specimen is found with the tubercles, and even considerable portions of the skin, a pink color. Often the belly is also spotted. (Hay.)

Size.—The male is 65 mm. in length and the female 85 mm.

Habitat.—The common toad, called by the earlier writers on American Herpetology "Land Frog," *Bufo lentiginosus americanus,* is found in the whole of eastern North America and southern Canada, west and south through Montana, Colorado, eastern Texas, Louisiana, Arkansas, Alabama, Kentucky, Iowa, and Missouri.

Missouri localities:—St. Louis, Jefferson, Franklin, Crawford, Phelps, Marion, Gasconade, Johnson, Jackson, Pettis, Buchanan, Jasper, McDonald, Stone, Taney, Ozark,

Howell, Oregon, Butler, New Madrid, Dunklin, Shannon, Cape Girardeau, St. François, Washington, Madison, St. Charles, Warren, Montgomery, Pike, Boone, and Randolph Counties. In Illinois it has been found in St. Clair, Madison and Monroe Counties.

Habits.—The habits of this toad are mostly nocturnal, although it is not uncommon to see a toad hopping about in the daylight. Usually, however, they hide away during the day in holes or under pieces of wood in shady corners, and come forth at evening to seek their food, which consists mainly of all kinds of insects, of which they devour an enormous number. It is related that an old toad ate at one time twenty-three squash bugs, and on top of these, ninety-four caterpillars. On account of this propensity for devouring insects, intelligent gardeners and farmers seek to induce toads to take up their residence on their grounds. No boy should be permitted to kill this harmless animal. The prey is taken by suddenly projecting the tongue from the mouth, and then withdrawing it with the insect sticking to it. Beside insects, toads will eat earthworms, and small crustaceans. The warty skin of the toad is full of large glands, which secrete a thick whitish fluid. This has very acrid properties, and doubtless serves to render the animal unpalatable to most of its enemies. It does not seem, however, to protect it from snakes. It is said that this secretion will make the mouth of dogs sore. During the winter the toad hibernates in holes and in the mud. (Hay.)

The toad appears early in spring after some warm days. Soon after emerging from its winter retreat, it repairs to the water for the purpose of depositing its eggs. These are laid in a long string, consisting of a double series of eggs enveloped in a tube of gelatinous material. Mr. E. E. Crosby states that he counted 8,840 eggs from one toad. The young hatch early and are of a darker color than usual with other Salientia. The length of a young mature toad is about one-half inch; the color grayish, with

small dark-colored spots. The notes of the male toad are heard principally during the breeding season, and may be given by the syllables ur-r-r-r-r. (Hay.)

Family Hylidae.

Upper jaw with teeth. Fingers and toes furnished with disks. The fingers with or without webs. Basal portions of fourth and fifth toe bound together by the integument. Teeth always on upper jaw; generally on vomers. Sternum with overlapping cartilages. Transverse processes of sacrum more or less expanded. Urostyle attached to two sacral condyles. Vertebrae procoelian.

Three genera are represented in Missouri.

Key to the Genera of Missouri.

Fingers without a web. Toes fully webbed. Digital disks small. *Acris.*

Fingers not webbed. Toes with little or no web. Disks small. *Chorophilus.*

Fingers webbed or not. Toes fully webbed. Digital disks larger. *Hyla.*

Genus acris.

Fingers free; toes webbed, the tips of the digits with small disks. Vomerine teeth present. Tongue broad, slightly excised behind, free for one-fourth of its length behind. Tympanum indistinct. Sacral process little expanded.

21. Acris gryllus LeConte. Cricket Frog. Savannah Cricket.

Rana gryllus, Rana dorsalis, Hylodes gryllus, Acris gryllus var. crepitans, Acris acheta, Acris gryllus bufonia.

Description.—Form frog-like. Head elongate, snout acuminate, projecting beyond the lower lip. Vomerine teeth in two patches between the choanae. Tongue broad, ovate, with or without a notch behind. Males with a large vocal sac, which opens beneath the tongue. Tympanic disk rather indistinct. Skin of back smooth, or with small or large tubercles. Belly and thighs granulated; throat smooth. Legs long, the heel passing near or beyond the snout. Two large metatarsal tubercles. Subarticular tubercles well developed. Fingers without webs; toes webbed to near the tips. (Hay.)

Three variations of this frog have been recognized:

1. Skin of back nearly smooth; hind foot from metatarsal tubercles longer than half the length of head and body. *A. gryllus.*

2. Skin of back considerably tuberculated. Hind foot, from metatarsal tubercles, shorter than half the length of head and body. *A. crepitans.*

3. Head and back covered with very large warts. Markings indistinct. Form toad-like. *A. bufonia.*

Color.—Body above brownish or cinereous. Occasionally green predominates, or there is considerable reddish, especially along the middle of the back. A triangular dark spot between the eyes; a white line from the orbit to the arm; two or three large oblique dark patches, often margined with white, on the sides. These markings are sometimes wanting. Beneath white, often varied with dusky. Chin and throat tinged with yellowish. Inner and hind parts of thighs reticulate. (*A. gryllus.*) Also a stripe of dusky color above and behind the fore legs. Legs cross-barred.

Habitat.—This species extends from New York to Florida, and west to Nebraska and Texas. The variety *gryllus* is, for the most part, southern in its range, while *crepitans* is more northern. In the State of Missouri it is found everywhere in suitable localities. The variety *gryllus* is reported by the late Dr. E. D. Cope in his Batrachians of North America as having been found by R. Kennicott in New Madrid Co., where he collected six specimens which he sent to the National Museum, where they are still kept under the number 3,560. I visited Dunklin Co., which is south of New Madrid Co., but there found only the variety *crepitans.*

Habits.—The most conspicuously active of our small tree-frogs is the Cricket Frog, a tree frog with wholly terrestrial habits. When it is frightened, it jumps high and far, repeating these leaps in remarkably rapid succession. It catches its insect food by leaping after moving insects it has sighted at a distance. Unlike the greater number of tree frogs, it cannot climb shrubs and trees, as the fingers and toes are too small. The Cricket Frog remains on the ground throughout the year, preferably along the muddy margins of pools and rivers. It is diurnal in its habits. If it is disturbed when near the water, it makes

a few of its remarkable leaps, swims vigorously a few strokes, and buries itself at the bottom of the pond. The name Cricket Frog was given to it, on account of its song, which bears a strong resemblance to the chirping of the black cricket. These tiny frogs sing in chorus in spring. The sound can be imitated by striking together two pebbles or two marbles, beginning slowly and continuing more rapidly for thirty or forty strokes. The male frog is the singer and in doing so inflates his yellow throat enormously. The Cricket Frogs are easily discovered while singing, because they do not hide under moss and grass, like the Pickering Tree Frog, but swell their throats while in full view on some water plants. The first warm days in early spring brings them out. Feb. 14, 20; Mar. 5; May 1; Sept. 7; Oct. 16.

Miss Mary C. Dickerson in the "Frog Book" gives the following account of their breeding habits:—"Their chorus is loudest in late April and early May, and it is then that the eggs are laid, attached to grass blades or leaves in the water. At this time the Swamp Tree Frog chorus has disbanded and the Pickering's *Hyla* is singing only at night.

"The development of this frog is less rapid than that of the Common Tree Frog, the Eastern Wood Frog, or the American Toad. The tadpoles may be found in the water as late as August. The final transformation takes place in September. The young tree frogs—as well as the older ones—seek shelter from the cold under stones and leaves at the margins of their brook or marsh. However, they have no long-continued hibernation, but renew their activity whenever the sun is warm or the south winds blow."

Genus CHOROPHILUS.

Digital disks all small, but the phalanx with a strong claw. Fingers free from web. Toes with little or no web. Vomerine teeth present. Tongue round or oval, slightly notched behind. Tympanic disk distinct. Sacral vertebra with its transverse process slightly expanded.

22. Chorophilus triseriatus Wied. Three-striped Tree Frog.

Hyla triseriata, Helocoetes triseriatus, Hylodes maculatus. Chorophilus septentrionalis, Chorophilus nigritus.

Description.—In general appearance this species is of an elongate form. Head longer than broad. Upper jaw rather pointed, projecting over the lower. Tongue elongate, slightly notched, and free behind for about one-third of its length. Tympanum circular in outline, about half the longitudinal diameter of the eye. Vomerine teeth between the choanae. Femur and tibia nearly of the same length. Palm with numerous rounded tubercles. Two small plantar tubercles. Basal part of outer toes bound together by the integument. Small webs between all the toes. First finger of males greatly swollen at base. Skin of throat greatly distended in males and thrown into longitudinal folds when the vocal sac is at rest. Dorsal surface finely, ventral surface coarsely, granulate. Upper surface of head, limbs, excepting the femora and in the males the throat, smooth.

Color.—Above yellowish green to ash-gray or dull black, with spots and longitudinal stripes of brown or black. Below whitish, sometimes with brown specks on the sides and belly. The upper jaw is margined by a dark stripe, which is widest in front and becomes gradually narrower on each side to the angle of the mouth. Above this stripe is another pale one which passes just beneath the eye and extends backward, between the angle of the mouth and the tympanum, to the base of the fore leg on each side. Both these bands are continuous around the snout. Above the pale stripe are dark bands, one on each side, which include the nostrils, rapidly widen to the eyes, and are continued behind them to or beyond the middle of the sides. Two other bands begin behind the eye, extend along the sides of the back, and terminate a short distance above and in front of the femora. A median dorsal band begins on the snout, expands abruptly between the eyes, and terminates at about two-thirds the distance from the snout to the posterior end of the body. At its posterior termination lie two short stripes, one on each side of the middle line, reaching back toward the end of the body. Legs colored like the back above, with dark spots; pale below. Sometimes the color of the whole back is a sooty black, and the stripes and spots only faintly indicated. (Garman.)

Size.—Female, length of body 33 mm.; from tip of snout to axilla 11 mm. Femur 12 mm.; tibia 13 mm. Tarsus and fourth toe together 20 mm.

Habitat.—It is reported from New Jersey to Montana, south to Arizona (Flagstaff, Hurter), New Mexico, Okla-

homa, Kansas, Nebraska, Colorado, Dakotahs, Ohio, Illinois, and Missouri. Missouri localities:—Montgomery, St. Charles, Franklin, Jackson, Jefferson, and St. Louis counties. In Illinois, Madison and St. Clair counties.

Habits.—With the first mild spring days, before all the snow and ice of winter have disappeared, the loud trill of this small species may be heard from pools and ditches. The note is so resonant that on quiet evenings it may be heard a half mile or more and is commonly attributed to larger frogs. Later in the season the note is not heard and the species is not often seen. It feeds upon insects. Hemiptera, Coleoptera, and other insects have been found in its stomach. It is not commonly met with. March 17th I caught over a dozen from a ditch into which I had chased a *Thamnophis radix.* Other dates of capture:—Apr. 22, 23.

Genus HYLA.

Digits expanded into discs at their tips. Toes webbed, fingers more or less webbed, or free. Tympanum distinct. Eustachian tube well developed. Tongue broad, entire or slightly excised, adherent, or more or less free behind. This is a genus of arboreal frogs. Four species are found in the State of Missouri. (Garman.)

Key to Missouri Species.

Green or gray, with a yellow stripe on each side. *carolinensis.*

With an X-shaped dusky mark on the back. Snout produced in front of nostrils. Palms and soles not granulate. *pickeringii.*

Olive or green above, with small, irregular dark spots. A V-shaped mark between the eyes. Toes one-half webbed. Tympanum one-half the eye. *squirella.*

With numerous irregular dark markings. Palms and soles granulate. Snout bluntly rounded; nostrils almost terminal. *versicolor.*

23. Hyla carolinensis Pennant. Carolina Tree Frog. Green Tree Frog. Bell Frog.

Rana viridis arborea, Hyla viridis var. B, Hyla cinerea var. semifasciata, Rana arborea var., Calamita carolinensis, Calamita cinerea, Rana bilineata, Hyla lateralis, Calamita lateralis, Hyla viridis, Hyla semifasciata, Hyla cinerea.

Description.—Head rather small, about as long as broad. Snout rather pointed, sides of snout somewhat oblique. Tongue short, free at the sides and for about one-third its length from behind; notched behind. Vomerine teeth in two, short, transverse series between the choanae. Tympanum very distinct, about two-thirds the diameter of the eye. Body slender. The extremities are slender and elongate also. The heel of the extended hind legs marks the end of the muzzle. Tibia about half the length of the body. Webs and fingers small, disks large; that of the first digit smallest. Webs extend to the base of the distal phalanx in all the four toes. The third toe is a little longer than the fifth; fourth toe the longest. There is a soft tubercle at the base of the inner toe and a very rudimentary one at the base of the outer. Disks not as large as those of the fingers. The surface above is smooth or very faintly granulated. The belly and lower parts of thighs are strongly granulated; the throat moderately so.

Color.—Color above varies from bright pea-green through various shades of gray to almost black, with specks of orange on the back, and a wide buff or light yellowish stripe, beginning at the tip of the snout and extending along the upper jaw, under the tympanum and along the side, to the posterior end of the body, or terminating on the side of the abdomen. Iris golden, pupil elongate in life. Color beneath yellowish or flesh-color, unspotted; throat at the angle of the mouth yellowish. Legs green or gray above, pale beneath; discs and webs pale. A pale stripe extends along the posterior face, and upon the base of the arm to that of the fourth finger. A similar pale stripe extends along the posterior face of the tarsus and is continued upon the fifth toe of the posterior leg. (Garman.)

Size.—Male. Length of head and body 60 mm.; from tip of snout to axilla 20 mm. Femur 26 mm. Tibia 28 mm. Tarsus and fourth toe together 38 mm.

Habitat.—Found in the southern United States, both east and west of the Mississippi. It is reported from the Carolinas, Georgia, Florida, Louisiana, Mississippi, Texas and Missouri. The first knowledge of this species in the State of Missouri I had through Dr. Cope's Batrachia of North America, where he cites two specimens, No. 1070 of the Smithsonian Collection, sent in by Dr.

George Engelmann, giving St. Louis as the place of collection. In my long experience of collecting in this neighborhood I have never been able to detect one. Several times I collected in Dunklin County, and when investigating this matter I was told of a frog, called the Bell Frog. Until 1909 I was unable to procure one. In that year Mr. A. H. Howell of the United States Biological Survey visited me. As his itinerary was down to New Madrid Co., I drew his attention to this frog, and on his return he brought me two fine specimens (males), which he had collected at Cushion Lake, near Portageville, New Madrid Co., on May 5th. On July 12th Dr. F. Kingsolving of Hornersville, Pemiscot Co. also sent me two specimens from his neighborhood.

Habits.—This is the nicest Tree Frog of our fauna. It lives on the leaves of plants, frequenting especially lily pods and other aquatic vegetation at the edges of lakes. It occurs also at times in corn fields, on fences, and in and outside of well houses. Its food consists of insects, particularly the common fly. If it sees a fly at a distance of three or four feet it will make a leap to catch it, seldom failing. When calling the throat-poach is inflated, the body over the lungs swelling and relaxing forcibly.

Mary C. Dickerson describes the chorus as heard in southern Illinois as follows:—"Its note resembles the tone of a small cow-bell heard at a distance. Where abundant about water, the frogs are very noisy just before dusk, the chorus being broken, however, by longer or shorter intervals of silence. A single note is first heard, and, as if that were a signal, it is taken up and repeated by a dozen noisy throats until the air is resonant with sound. After a while it ceases as suddenly as it began, to be again resumed after a short period of quiet."

24. Hyla pickeringii Storer. Pickering's Frog. Peeping Frog. Spring Peeper.

Hylodes pickeringii, Acris pickeringii.

Description.—Head a little longer than broad; snout rather pointed, with the muzzle projecting well beyond the lower lip. Nostrils small,

nearer to the muzzle than the eye. Canthus rostralis distinct; loral region concave. Tongue heart-shaped, free behind. Vomerine teeth in two small groups just behind the level of the choanae. Inner nares more widely separated than the outer. Tympanum small, hardly visible. Body very slender. Limbs slender and weak. Fingers longer and more slender than usual, the third especially long; web wanting between the first and second fingers, almost imperceptible between the others. Toes also long and slender; webs very small, minute between the first and second toes and only reaching to the base of the antepenultimate phalanx of the fourth toe. Disks at tips of digits only moderately large. Skin mostly smooth above, granulate beneath and on sides. Palms with a few small tubercles, and one large one. Base of first finger with a tubercle. Soles smooth with a well-developed tubercle at the base of the first toe and a minute one at the base of the fourth and fifth, the latter sometimes wanting.

Color.—Above some shade of gray or brown, with narrow lines of dark brown or black, the principal of which are disposed on the back in the form of a large letter X; yellowish beneath. The ground color is usually pale brown. The anterior arms of the X-shaped mark converge from just behind the eyes to the middle of the back, where they meet; from this point the two posterior arms diverge posteriorly and ventrally. Another mark behind this sometimes resembles an inverted letter V. A dark band, well defined above but fading into the ground color below, extends along the side of the snout to the anterior border of the eye. A wider band, which includes the tympanum, extends from the posterior border of the eye toward the base of the anterior leg. Two lines, one above each eye, sometimes unite across the median line and form a triangular spot. Iris golden, pupil black in life. The legs above are like the back in color and are banded with brown, two or three wide bands occurring on the femora and on the tibiae. A dark line is generally present on the posterior surface of all the legs. A dark spot overlies the vent. Body and legs uniformly pale beneath, or with the throat yellowish, speckled with dusky. (Garman.)

Size.—Male. Length of body 30 mm.; from tip of snout to axilla 10 mm. Femur 13 mm.; tibia 13 mm.; tarsus and fourth toe together 20 mm.

Habitat.—Eastern North America from Maine to Manitoba, and south to South Carolina, Michigan, Ohio, Indiana, Illinois, and Missouri. Missouri localities: St. Louis County. Illinois: St. Clair and Monroe Counties.

Habits.—*Hyla pickeringii* is generally found in low, marshy land in the open or in pools in the woods. Its voice can be heard with distinctness at least a quarter of a

mile away. It is somewhat difficult to isolate a single voice from the chorus. From a distance it reminds one of the whistle of snipes. If one is once caught sight of, it is not difficult to see others, especially if the floating leaves and sticks in the shallow water are pushed aside. Many tiny, yellow or brown, frogs will swim out among the leaves. Most of them will be males, as they far outnumber the females. The best time to catch them is at night, when it seems they do not hear as well. It is not as difficult as might be supposed to locate them by means of their inflated white throats.

Dates of capture.—April 4th (plentiful); May 6; Oct. 7, 15.

25. Hyla squirella Bosc. Southern Tree Frog. Squirrel Frog.

Dendrophyas squirella, Calamita squirella.

Description.—Head moderate, a little broader than long. Snout rather acute. Tongue circular, slightly nicked, and free behind. Vomerine teeth in two small patches between the choanae. Canthus rostralis distinct, loral region slightly concave, interorbital space a little broader than the upper eye lid. Eyes prominent. Tympanum distinct, one-half the diameter of the eye. Body more slender than in *Hyla versicolor*. Limbs moderately developed. Hind limb appressed forward along the body, the tibio-tarsal articulation reaching nearly to the tip of the snout. Fingers very slightly webbed at the base. Toes half-webbed. Disks smaller than tympanum. Subarticular tubercles moderate. Body above smooth, beneath granulated on the abdomen and thighs.

Color.—Above olive-green, with irregular dark blotches, which are sometimes wanting; a dusky bar between orbits; an indistinct band from the nostril to eye; a white line along upper jaw to shoulder. Beneath greenish-white. Throat sometimes with a few dark spots; extremities obscurely marked with darker above, flesh-colored beneath.

Size.—Length of head and body 32 mm.; from tip of snout to axilla 10 mm. Femur 15 mm.; tibia 15 mm.; tarsus and fourth toe together 20 mm.

Habitat.—Southeastern United States, west to Louisiana, Arkansas, Missouri and Indiana. To date I have never found a specimen in the State of Missouri, but in-

clude it in this list on the authority of Dr. Eugene S. Meek of the Field Museum of Natural History, Chicago, Ill., who collected some at Greenway, Clay Co., Arkansas. Clay County adjoins Dunklin Co., Mo., to the east, and no doubt this species will eventually be found in Missouri.

Habits.—The Squirrel Frog lives in both low and tall vegetation. It may be found on the vines and shrubs of the garden, or on the margins of lakes and rivers, or even in the trees of these localities. It conceals itself under the decaying bark of trees or under dead logs. My friend, the late Mr. Louis Schoelch, when collecting beetles in 1891, near Mobile, Ala., caught a number of these frogs, while mowing bushes with his net to secure beetles. He presented them to me, and they are still in my collection.

26. HYLA VERSICOLOR LeConte. Common Tree Frog. Chamaeleon Tree Frog.

Dendrophyas versicolor, Hyla richardi.

Description.—Form heavy and almost toad-like. Head considerably broader than long; the snout rounded; the space in front of the eyes concave. Tongue large, circular, notched behind, where it is free for about one-half its length. Vomerine teeth in closely approximated patches lying between, or a little behind, the choanae. Eyes large and protruding. Tympanic disk about two-thirds the diameter of the eye, with moderate fold of skin above it. Body stout and clumsy; the breast crossed by a broad fold of skin. Extending the hind leg along the side, the heel reaches to the back of the orbit. Anterior limbs short, stout, fingers and toes broad, dilated into disks; the one on the third finger being nearly equal to the tympanum; the disk of the inner finger is smaller than the rest; the first finger opposed to the rest. The web is more extended than in other species of the United States. Toes webbed to near the tips.

Upper surface of the body with numerous smooth warts; belly and under surface of the thighs granulate, the band across the breast less so. Subarticular tubercles moderate. A large tubercle on the base of the pole. Another one on the base of the first toe. A very distinct fold along the inner side of the tarsus. Males furnished with a large gular sac, which opens on each side under the tongue. (Hay.)

Color.—Grayish or olive brown, with irregular darker markings and dark cross-bars on the limbs; sides of thighs yellow, with a black net-work; beneath immaculate. There is a great variation in the

ground color, dependent on a number of circumstances, but there is always a whitish spot beneath the eye. Young specimens taken on the leaves of plants are green, with few or no dark marks.

Size.—Head and body 50 mm.; from tip of snout to axilla 17 mm.; femur 25 mm.; tibia 25 mm.; tarsus and fourth toe together 32 mm.

Habitat.—Common throughout the state, as well as through the whole eastern and northern United States. Missouri localities:—St. Louis, Jefferson, Shannon, Butler, Oregon, Ozark, Stone, Jasper, Jackson, Johnson, Lewis, Pike, Warren, Randolph, Montgomery, and St. Charles Counties.

Habits.—The Chamaeleon Tree Frog is the tree frog *par excellence* in this state. It is common, and in some places abundant. Its voice is a loud, coarse, resonant trill, uttered with a uniform pitch, and continued for two or three seconds. It is heard about bodies of water in spring, when the sexes are depositing and fertilizing the eggs. Later in the season it proceeds from fences, hedgerows and orchards, as well as from the forest. They are especially noisy towards evening after a rain; but they may be heard at any time during dark and drizzly days. It readily takes the color of the object on which it rests, thus concealing itself successfully. Its colors vary from a deep brown to gray, and nearly white to bright green. The change of color is not rapidly accomplished. The favorite color is gray, which is identical with that of the lichens of the trees which it inhabits. (Cope.)

Dates of capture.—Apr. 8, 18; May 29; Oct. 15; Nov. 7.

Family Scaphiopodidae.

Vertebrae procoelian; no costal elements or coccygeal diapophyses; diapophyses of ninth vertebra much dilated, thin, and triangular; urostyle without condyloid articulation, its axial portion restricting that of the sacrum and connate with it; external metatarsi bound; distal phalanges continuous, simple. Manubrium cartilaginous. Tongue rounded, nearly entire.

The small number of species embraced in this family are of stout toad-like habit, and furnished with a shovel-like development of the cuniform bone and a coriaceous posterior digital palmation, to aid

them in removing earth while making their subterranean abodes. Many of them very seldom come to the surface of the earth, and then only in darkness; for this habit the verticle cat-like pupil is an adaptation, a peculiarity not exhibited by the toads, which are crepuscular. (Cope.)

Genus SCAPHIOPUS.

Pupil erect. Tongue subcircular or oval, entire or slightly nicked, and free behind. Vomerine teeth in two small groups. Tympanum more or less distinct or hidden. Fingers generally with a rudiment of web; toes webbed; tips of fingers and toes not dilated. Inner metatarsal tubercle shovel-shaped; outer metatarsal separated by web. Omosternum cartilaginous, rudimentary; sternum a cartilaginous plate. Vertebrae procoelian; sacral vertebrae with rather strongly dilated diaphyses, confluent with coccyx. (Boulenger.)

27. SCAPHIOPUS HOLBROOKII Harlan. Hermit Toad. Holbrook's Spade Foot.

Rana holbrookii, Scaphiopus solitarius.

Description.—Snout rounded, nostrils nearer the tips of the snout than the eye. Interorbital space as broad as, or a little broader than, the upper eyelid; upper surface of head bony, rather smooth; tympanum distinct, half the width of the eye. Tongue sub-circular, or oval, nicked behind. Vomerine teeth in two small groups on a level with the hind edge of the choanae. Two round glands on each side of the thorax, near the axilla. Fingers short, with a rudiment of web, first a little longer than second; toes short, webbed to the tips; subarticular tubercles indistinct; three metatarsal tubercles. Metatarsal shovel longer than first toe. The hind limb being carried forward along the body, the tibio-tarsal articulation reaches the shoulder of the tympanum. Skin of back minutely tubercular, of sides more coarsely, beneath nearly smooth. Male with a subgular vocal sac.

Color.—Brownish or olive above, marbled with darker; edge of the metatarsal shovel black, male during the breeding season with black rugosities on the inner side of the first two fingers. The tubercles on the sides with a whitish spot.

Size.—Length of head and body 62 mm.; from tip of snout to axilla 26 mm.; femur 25 mm.; tibia 20 mm.; tarsus and fourth toe together 34 mm.

Habitat.—Its range is from Massachusetts to Florida, west to Texas, north to Arkansas. Specimens from Cambridge, Mass., are nearly unicolor, while Florida forms are lightest and most varigated. The writer includes this

species in his list, as it has been reported from Greenway, Clay Co., Ark., where it was collected by Dr. Eugene S. Meek of the Field Museum of Natural History, and, no doubt, will eventually be found in the Sunken-lands of Missouri.

Habits.—Colonel Nicholas Pike in Bulletin No. 7 of the American Museum of Natural History, gives a very able life history of this toad, from which I quote the following:—"The harmless little creature is still not uncommon, *if you only know where to find it.* There lies the difficulty—so few do know—and, excepting some naturalists, very few would distinguish it from a common toad. It must of course be hunted for in secluded places, and woody hill-sides, but I will venture to say that even the most knowing, in nine cases out of ten, will only find a Spadefoot by accident.

"They make circular holes in the ground about six inches deep, somewhat turnip shaped. A few minutes sufficed for them to burrow out of sight. The long feet, with the horny excrescence serving as an additional toe, and the strong curved fingers enable the Spade-foot to make the excavation rapidly. This is not by any means the completion of its home. The inside has to be worked smoothly, and the earth prevented from falling in.

"This is done by the animal working its body with a circular motion, and the operation would go on for an hour or more, and the liquid exuding from its pores worked into the earth made it smooth, and formed a curious little dwelling when completed. Round the top was a layer of viscous matter, and woe betide any unwary insect that alighted on it. Closely concealed lay Spadefoot, only the bright eyes visible, ever on the watch, and unerring in its aim when any luckless fly intruded on the threshold. They appeared to be greedy feeders.

"This I find is the usual summer residence of the Spade-foot, and when once domiciled, it rarely leaves

home in the day-time. No two ever inhabit the same hole, hence the name Hermit Spade-foot, or *solitarius.*

"When the cold nights of fall begin, the Spade-foot leaves its summer home and looks out for one more suitable for the winter season. It generally chooses the warm southerly side of a hill, and excavates deeply for its new quarters. I found one over three feet below the surface.

"Mr. Andrew Nichols in the Essex County Journal of Natural History states that in Danvers, Mass., about the years 1812 and 1825, after a great rain in summer, and on August 12, 1834, and again on June 16, 1842, the Spade-foots appeared for breeding purposes, never being noticed in the intervening years—a most remarkable fact."

Family Ranidae.

Upper jaw furnished with teeth. Vomerine teeth present or absent. Transverse process of sacral vertebra little or not at all expanded. Vertebrae procoelous. Ribs none. (Hay.)

Genus rana.

Teeth on upper jaw and on vomers. Tongue free behind and notched. Tympanum usually distinct. Fingers free. Toes webbed. Outer metatarsal separated by a web.

Contains more than one hundred species, living in all countries except southern parts of South America and New Zealand. Cope assigns thirteen species to North America, seven of which occur in Missouri. (Hay.)

Key to the Missouri Species of Rana.

Without a black ear patch.

Dorso-lateral dermal folds present; heel reaching nearly to the muzzle or beyond it; back with well defined dark brown, pale edged oval or round spots. *pipiens.*

Dorso-lateral dermal folds large, with smaller ones between; heel to front of orbit; tympanum one-half the diameter of eye; brown spots so large as to reduce ground color to a net-work of narrow lines; three phalanges of fourth toe without web. *areolata.*

Dorso-lateral dermal folds four; the quadrate spots of back in rows; two phalanges of fourth toe free of web; heel to front of orbit, or sometimes to muzzle. *palustris.*

Dorso-dermal folds present; skin of back rough; tympanum nearly as large as eye, or larger; toes webbed nearly to tips; heel not reaching muzzle; dark blotches on back; size moderate. *clamitans.*

No dorso-dermal folds; tympanum usually as large as eye, or larger; toes webbed to tips; usually some blotches above; size large. *catesbiana.*

Sides of head with a black patch.

Head in distance from snout to vent 3.5 times; tympanum one-half the eye; skin of middle of back smooth; heel to middle of orbit. *cantabrigensis.*

Head in length three times; tympanum two-thirds the diameter of eye; skin of middle of back rough; heel to muzzle or more. *sylvatica.*

28. Rana pipiens Schreber. Leopard Frog. Common Frog.

Rana halecina, Rana virescens, Rana virginiana, Rana aquatica, Rana utricularia, Rana oxyrhynchus, Rana berlandieri.

Description.—Head varying in relative length, being contained in length of head and body from 2.5 to 3.5 times. Vomerine teeth in two slightly oblique patches between the choanae. Tympanum about as large as the eye. Head rather elongated. A glandular fold along the upper jaw and a well-marked one on each side of back; generally a pair of ridges on coccyx. Femur less than tibia; the latter more than one-half length of head and body. Toes moderately webbed.

Color.—Ground color ashy, olive or bright green above; below uniform white or yellowish. The upper surface with a number of rounded or oval brown spots, and these usually bordered with yellowish. The spots between the dorso-lateral folds are larger, and may be arranged in two or three rows, or may be irregularly placed. Outside these folds are two or three rows of smaller spots. The upper surfaces of the limbs are more or less conspicuously barred or spotted. Males have vocal sacs, which open by a small slit near the angle of the mouth. These sacs appear to be protruded through the slits. (Hay.)

Size.—Head and body 88 mm.; from tip of snout to axilla 33 mm. Femur 48 mm.; tibia 52 mm.; tarsus and fourth toe together 70 mm.

Habitat.—Maine to Mexico, but mostly in the eastern United States. Common everywhere in Missouri.

Habits.—The Leopard Frog is our commonest, best known, and most beautiful frog. It makes its appearance

early in the spring—March 17th. Its cry is one of the earliest of vernal notes. Sometimes it croaks during the warm days of winter. The eggs are laid in masses in shallow water. They may be attached to sticks or free in the water. The whole laying is enveloped in a gelatinous mass about five inches in diameter and two and one-half inches thick, and may contain from five to six thousand eggs. The eggs are black in color and are so close together that the entire mass is dark, notwithstanding that the gelatinous mass is perfectly transparent.

29. Rana areolata Baird and Girard. Gopher Frog.

Rana areolata capito, Rana areolata circulosa.

Description.—Head large, rather pointed, with a marked concavity between the nostrils and the eyes. Eyes large, prominent. Nostrils midway between the eye and the tip of the snout. Tympanum oblong, nearly circular, about two-thirds the diameter of the eye. Internal nares large, open transversely, elongate. Vomerine teeth well developed, nearly meeting in the center and situated between the choanae. Tongue large, fleshy, longer than broad, with the cornua small, and wide apart. Body stout. Hind foot appressed to the side, the heel reaches to the orbit. Fingers not webbed. Toes moderately webbed and well scalloped. The terminal two and a half phalanges of longest toe, however, are almost entirely free. Subarticular tubercles on the fingers and toes. No tubercle on the outer edge of sole. The upper surface of the back and head is generally smooth; the upper part of the sides slightly studded with tubercles as also the upper part of the femur and tibia, but not so strongly. The posterior faces of the femur granulated. The whole lower side is entirely smooth. A rather broad but low fold of skin can be traced from above the tympanum along the sides of the back nearly to the thighs. A low wide ridge branches off from the dermo-lateral ridge behind the tympanum. Males with a vocal sac on each side. Two glandular ridges, which run together on each end, but are separated about 5 mm. in the middle on the urostyle.

Color.—The entire upper part and sides of body are covered with a number of brown blotches encircled with light yellow. These blotches are most distinct and crowded anteriorly, and do not invade the outer edge of the dermolateral fold. The spots on the back are generally arranged in longitudinal rows. The ground color of the upper surface of the fore limbs is yellowish brown with vermiculation of darker brown. The hind legs have numerous parallel and transverse dark brown bars, three or four on the thighs, four or five on the tibia, three on the tarsus, and several on the edge of the foot. The bars are

broader than their interspaces, and are margined by yellow lines. The lower parts are yellowish-white, unspotted, including the interior and inferior surfaces of the limbs. A few scattered blotches are seen along the posterior half of the lower jaw and on the breast in front of the arms. The buttocks are yellowish-white, with some marbling of brown. The center of the tympanum is white. (Cope.)

Size.—Length of head and body 98 mm.; from tip of snout to axilla 38 mm. Femur 44 mm.; tibia 48 mm.; tarsus to end of longest toe 68 mm.

Habitat.—This frog so far has been reported from Texas, Georgia, Indiana, Illinois, and Missouri. Missouri localities:—Montgomery and Johnson Counties. (B. M. Stigall.)

Habits.—In the year 1906 my friend, Mr. Edgar M. Parker, a young naturalist, sent me a frog, which I recognized at once as this species. June 6th, 1908, I went to Montgomery City to learn more of this frog. My friend and I went out early in the morning to the place where he had captured the first specimen in a marshy corner of a small pasture just outside of the town. Here we found the holes in which the frogs live and hide. The holes seemed to be abandoned crayfish holes, very likely widened by the present owners. Although these holes were very numerous, by diligent search we discovered only three which were occupied. The inhabited holes are easily recognized as the entrance as well as a little platform in front of it is worn smooth. Here the frog watches for its prey. As soon as it hears an unusual noise or sees someone it creeps back in the hole. It can then only be secured by digging for it. All the frogs that we secured that day were not deeper down than we could reach with our hands —about 18 inches. Curiously enough they made no attempt to recede farther when we reached for them. Had they dropped to the bottom we never could have captured them, as some of the holes were three or four feet deep with water at the bottom. My friend had heard of another haunt of these frogs in an embankment on the side of the road. I should never have looked for frogs in such

environments. As we approached we saw a frog slide back into his hole, which was not as deep as some of the others. We dug for him and as I neared him he retreated, and finally we heard him splash in the water. He was now beyond reach, but by a little strategy I secured him. I moved my closed fist backward and forward in the hole like the plunger of a pump. After a few strokes the frog could not withstand the suction and I felt him bumping at my hand. I then secured him without difficulty. So far I have only caught one away from his home, just about daybreak, while he was hopping in the grass. This frog is probably an early riser, preferring dawn to full daylight. The frog is well known to the farmers of this neighborhood, many of them being killed when the grass is mowed.

Dates of capture.—June 6; July 19, 26.

30. Rana palustris LeConte. Spring Frog. Swamp Frog. Pickerel Frog.

Description.—Head short, rather obtuse. Margin of lower lip slightly notched on each side of symphysis, leaving a projection in the middle. Tongue with two posterior lobes; free for half its length posteriorly, and also on the sides. Eyes large, prominent. Tympanum circular, about two-thirds the diameter of the eye. Nostrils about midway between the eye and the tip of the snout. The vomerine teeth are in two transverse patches between the choanae. A glandular ridge extends from the middle of the inferior edge of the tympanum to a point above the middle of the humerus. There are four thick glandular folds on the back; the external or dorso-lateral ones begin above the tympanum. A pair of slight ridges near the middle of the pelvic region. The interorbital space, two-thirds the width of an eye-lid. The tubercles of palm are well developed. The first finger is longer than the second, and equal to the third. The internal cuniform tubercle is small and weak, without an acute edge. Toes not fully webbed, the edges of the webs deeply scalloped, leaving two phalanges of the fourth toe free. The inferior and posterior parts of the thighs are granulated.

Color.—Body pale brown, with two longitudinal rows of squarish spots of dark brown color on the back and on each side; yellowish white beneath; posterior half of the thighs bright yellow, mottled with black. A dark brown spot on the top of each eye-lid and another near the snout. A blackish line extending from the nostrils to the eyes.

The upper and lower jaw yellowish white, spotted with dark brown. The tympanum is bronze, with a dark spot in the center. Arms with black blotches. Legs with transverse bars of the same color continued nearly to the end of the toes.

Size.—Length of head and body 69 mm.; from tip of snout to axilla 25 mm. Femur 40 mm.; tibia 40 mm.; tarsus and fourth toe together 54 mm.

Habitat.—This species is found from New Brunswick west to the central plains, south to Louisiana and Florida. Missouri localities:—Cliff Cave, St. Louis Co., Washington, St. Charles, Jefferson, Cooper, Marion, Montgomery, Crawford, Butler, Stone and Dunklin Counties.

Habits.—This species prefers cold springs and streams. In Green's Cave, near Sullivan, Crawford Co., I collected one at a place in the cave nearing complete darkness. In small streams it is generally found under slabs of rock partly in the water. Meadows and fields near brooks are the home of the Pickerel Frog. No other frog presents a coat of such brilliant metallic luster as a young Pickerel Frog after being in the bright sunlight for some hours. The young, when in the mud for sometime are so dark that the spots are hardly discernible. The Pickerel Frog has no large external vocal pouches, but the throat, the region back of the eyes and under the ears, as well as the sides, all expand considerably during croaking, which is low and prolonged, resembling somewhat the sound produced by tearing coarse material. The species has a distinctly unpleasant odor, due to a secretion of the skin, for which reason it is not considered edible. It is called Pickerel Frog because of its use to a great extent as bait in pickerel fishing. The irregular egg masses are about two inches in diameter and contain between two and three thousand eggs. These frogs spend a good deal of their time hunting, probably for caterpillars, meadow caddisflies, butterflies, flies, gnats, and beetles. They are known to feed on snails, small crayfish, and aquatic amphipods

and isopods. They are quite common in suitable localities, but are not found on the Great Plains of the West, where the Leopard Frog holds supreme sway among frogs.

31. Rana clamitans Latreille. Green Frog.

Rana clamata, Rana fontinalis, Rana melanota, Ranaria melanota, Rana flaviviridis, Rana horiconensis, Rana nigricans.

Description.—Head broad, contained in length of head and body three times. Snout rounded. Top of head plain, without any concavity. Nostrils large, oval, situated on the rounded and indistinct canthus rostralis, a little nearer to the snout than to the eye. Eyes large. Tongue large and fleshy, strongly nicked behind, from where it is free for one-fourth of its length. The choanae are large and open posteriorly, nearly opposite the anterior canthus rostralis. The vomerine teeth are in two oblong patches between the choanae. The tympanum is about two-thirds the diameter of the eye; males, 11 mm.; females, 8 mm.

Body and limbs very stout and massive, legs short. The forearm and hand nearly equal in length. The third finger longest, first and fourth nearly equal. Femur, tibia and hind foot nearly equal and less than half the length of head and body. The third toe is longer than the fifth; fourth, the longest. The web between the toes well developed and extending to the tips. Subarticular and metatarsal tubercles moderately developed.

Skin more or less mammillated above and on the sides by coarse pustuliform prominences, largest on the sides. A groove passes from the back of the eye over the tympanic disk and downward behind it, ending in front of the arm. There are two dorso-lateral glandular folds, which start at the upper eyelids and run back to the pelvic region. Over the tympanic disk a branch is given off, which passes down behind the disk and terminates over the arm. The groove described above lies between the disk and the branch. Hind limb appressed along the side brings the heel between the eye and the snout.

Color.—The color varying from greenish olive to brown; in life often bright green toward the head. On the back there are usually numerous small irregular blotches of dark brown, and larger ones on the sides. The hind legs are crossed by rows of small spots. The hinder surface of the thighs is granulated and of a yellow color, with spots and mottlings of black. The lower jaw and throat are marbled with brown, otherwise pale below. The tympanum has a black spot in the center.

Size.—Length of head and body 85 mm.; from tip of snout to axilla 33 mm. Femur 43 mm.; tibia 43 mm.; tarsus and fourth toe together 66 mm.

This species may be distinguished from *Rana catesbiana* by the presence of two dorso-lateral folds.

Habitat.—Distributed over the eastern United States and Canada to the Plains. Found all over Missouri in abundance.

Habits.—This frog is found along the muddy banks of brooks and ponds. Walking along a little stream, we may hear a sound, a high pitched cry, ahead of us and see a frog jump into the water, hiding under the leaves and in the mud. This is the Green Frog. Because of its peculiar cry or scream, it was called the "Screaming Frog." This frog is more aquatic than most frogs with the exception of the Bull-Frog. The Green Frog moults four or more times each year. If not in water when moulting, it will swallow the moulted skin like the toads and the Leopard Frog.

Mary J. Dickerson in her admirable book gives the following account:—"During almost any of the warm months of the year we may find Green Frog tadpoles changing to the adults. The hind legs grow rapidly, and may be conspicuously barred with dark color. The left arm appears first, thrusting itself out of the breathing-pore. Then the right one breaks through the skin. The changes in mouth and eyes begin. The tail is slowly absorbed. The ears are the last external sign to tell that the change is quite completed. Most curious is the fact that some tadpoles show the lateral folds and the coloring of the adult male or female long before the change is completed, while others take on the frog form entire before the lateral folds are well developed or before sexual coloring is evident."

Dates of capture.—Mar. 21; May 1, 29; Aug. 13; Sept. 1, 17; Oct. 3, 26. July 4, 1904, while collecting in Dunklin County, I came across a number of these frogs in a dark cypress swamp, where they were hiding beneath brush piles. All were of a dark color.

32. Rana catesbiana Shaw. Bull Frog.

Rana pipiens, Rana mugiens, Rana scapularis, Rana maxima americana aquatica, Rana conspersa, La Grenouille mugissante, La Mugissante ou Grenouille taureau.

Description.—Head moderate; snout rounded, sides oblique, canthus rostralis indistinct. Interorbital space either as broad as upper eyelid or much narrower. Nostrils oblique, half way between the eye and the tip of the snout. Vomerine teeth in two small groups, close together, between the choanae; four or five teeth in each patch. Tongue elongate, strongly notched behind. Tympanic disk the size of the eye or even larger. The third finger is the longest. No membrane or web. The tibia is not quite half the length of head and body. The fourth toe is the longest; third longer than fifth. Toes webbed to the tips. No dorso-lateral folds. A glandular fold begins at the upper eyelid, runs over and behind the tympanum and in front of the arm, ending on the breast. Between this fold and the tympanum is a sharp groove. Heel reaching to the front of the eye. Male with two internal vocal sacs.

Color.—The color of the upper surfaces in alcohol varies from reddish to olive and brown. In life the color may be pale yellow, green, brownish, or even deep brown. Below, the general color is white or yellowish. On the upper surface spots of brown may occasionally be almost entirely missing, but generally there are blotches of brown varying in size and number, sometimes running together. The outlines are not well marked. The sides usually with distinct marblings of brown. The thighs may be spotted on the upper surface; these spots may even form cross bars. The rest of the leg and foot may also be spotted or almost devoid of any brown markings. They may be conspicuously present on the throat, breast, belly and legs. The hinder part of the thighs is usually mottled and blotched. (Hay.)

Size.—This frog is the largest of our frogs, the body sometimes being 8" (203 mm.) in length, and the body and legs together 18" (450 mm.). Head and body 170 mm.; from tip of snout to axilla 62 mm.; femur 82 mm.; tibia 80 mm.; tarsus and fourth toe together 116 mm.

Habitat.—Eastern North America to the Rocky Mountains. Found everywhere in suitable localities in Missouri in abundance.

Habits.—This species lives in the waters of our brooks, rivers and lakes. It never strays away from the vicinity of the water in search of food. Its loud voice has given it its popular name of "Bull-Frog." Dr. J. H. Garnier in his Reptiles of Canada says that he has heard the Bullfrog at a distance of five or eight miles. Authors tell us

that when this frog is whipped it will cry much like a child. These frogs are very voracious, and seem to catch and swallow almost any living thing that they can possibly devour. They feed on crayfishes, small fish, insects, worms, snails, mice and even their own species. Prof. J. A. Allen says that one seized and swallowed a cedar bird which he had shot, although the wings and tail continued to protrude out of the frog's mouth. Others have been found with snakes (grass snakes) in their stomachs. (Hay.)

The tadpoles require two years for their complete development. The general color of the tadpole above is dark olive green, yellowish white below.

In this neighborhood this frog is hunted mostly at night. When bull's eye lanterns are used to find the frog, which will not move as long as the glare of the light is turned on it, it is readily secured by stabbing with a "gig." In daylight the frog is shot, when partly or all out of the water near the shore, or it is lured with hook and line baited with a piece of red flannel. This frog is much relished as an article of diet.

33. Rana cantabrigensis Baird. Cambridge Frog.

Rana temporaria subsp. cantabrigensis, Rana cantabrigensis cantabrigensis.

Description.—Head rather depressed, snout elongate, acuminate. Nostrils equidistant between orbit and end of muzzle. Vomerine teeth in two oblique groups, extending beyond the level of the hinder edge of the choanae. Interorbital space narrower than upper eyelid. Tympanum hardly two-thirds the diameter of the eye. Fingers moderate, first extending beyond the second. Heel to middle of orbit. A glandular ridge on the inner edge of the tarsus. Webs of toes short. Subarticular tubercles of fingers and toes moderate. Inner metatarsal tubercle rounded, rather prominent and obtuse edged. A minute external tubercle. Male with two internal vocal sacs. The skin between the dorsolateral glandular dermal folds smooth.

Color.—Above yellowish-brown; a dark vitta through the eye, extending and widening behind the tympanum, then tapering to a point at the posterior end of the upper jaw. Lateral fold of skin light colored, as is also in some old specimens a median dorsal line extending from

the snout to the anus; a narrow light line along the posterior faces of the tarsus; the sides are frequently black-spotted, sometimes only marbled with brown; the femora and tibiae are indistinctly cross-banded. The upper and lower lips are dark-edged, the lower with light colored interruptions. A brown band on the front of the humerus. Throat and thorax marbled with light brown. Posterior face of femur light brown, marbled with darker brown. (Cope.)

Size.—Head and body 64 mm.; from tip of snout to axilla 16 mm.; femur 21 mm.; tibia 23 mm.; tarsus and fourth toe together 36 mm. This specimen was presented to me by Mr. Alexander G. Ruthven of Ann Arbor, Mich., who collected it at Isle Royale in Lake Superior.

Habitat.—Northern North America. In the Report of the Smithsonian Institution for 1864 is given the Journal of an Exploration of Western Missouri in the year 1854, by Dr. P. R. Hoy, who collected in Cooper County four *Rana cantabrigensis*, which are still in the National Museum under the catalogue number 3,457. On the strength of this I have included this species in my list.

Habits.—As I have never seen this frog in his haunts and as other observers give only meagre accounts of its life history, I shall quote from Mary J. Dickerson's Frog Book as follows:—"This frog has the same delicacy of beauty, the same gentleness and alertness of expression, possessed by the Eastern Wood Frog. It would be surprising to find any great difference in its habits. It is probably silent, except in the breeding season, and is more thoroughly a land frog than are most of the species of *Rana*."

34. Rana sylvatica LeConte. Wood Frog.

Rana silvatica, Rana temporaria var. silvatica, Rana pennsylvanica.

Description.—A rather slender frog, with a broad head and long legs. Length of head contained in length of head and body 3 to 3.5 times. Snout rather pointed, the *canthus rostralis* distinct. Eyes prominent. Loral space concave. Nostrils oblique, situated just below the *canthus rostralis* and half way between the eye and the tip of the snout. Tympanum moderate, about two-thirds the diameter of the eye. The tongue is elongated, much longer than broad, free behind for half its length, and on the sides, the two cornua prominent. Teeth in two small, slightly elongate patches, placed with the axis inclined a little backwards,

and about intermediate between the choanae, their anterior edges being in the same line. The teeth in the upper jaw extend back to the gape of the mouth. The fore legs are well developed. All the fingers are perfectly free. The third finger is the longest; the first and fourth equal; the second the shortest. All are thickened at the base. Legs long, the heel reaching to the muzzle or beyond. Tibia longer than femur. One outer metatarsal tubercle and also a faint inner one present. Subarticular tubercles on fingers and toes feebly developed. Web leaving two phalanges of longest toe, and one of the others, free. The skin of the back, the sides, and upper surfaces of the legs is provided with numerous sharp points which produce a slight roughness to the sight and touch. A dorso-lateral glandular fold starts at the corner of the eye and continues along the side to near the vent over the tympanic disk. This fold gives off a rather indistinct branch, which bends down behind the disk and terminates over the arm. No other folds between the dorso-laterals. Another glandular fold begins near the corner of the mouth and stops just over the arm. The hinder surface of the thighs somewhat granulated.

Color.—In alcoholic specimens the color of the upper surfaces of body and limbs varies from pale reddish-brown to ashy or dark gray; the sides may be pale yellow or brown; beneath whitish. There may be a few indistinct spots on the pelvic region of the back, while the sides may be somewhat mottled with dusky. Limbs distinctly or indistinctly barred with brown. A dark stripe at the base of the humerus in front. A black stripe from the snout to the eye. A triangular brown ear patch. A white stripe from the snout and along the upper lip to the arm. Upper and lower lips marbled with brown and whitish. In life the colors undergo considerable change, according to the surroundings. Farmers call this the "Red Frog." (Hay.)

Size.—Length of head and body 64 mm.; from tip of snout to axilla 24 mm.; femur 32 mm.; tibia 36 mm.; tarsus and fourth toe together 50 mm.

Habitat.—This species occurs from Maine to the Athabasca River and south to South Carolina and Missouri. Cope in his Batrachians of North America reports one specimen, No. 3,453, from St. Louis, sent by Dr. George Engelmann to the Smithsonian Collection. So far I have found this frog only near Marble Cave, Stone Co., Mo. This frog is quite rare.

Habits.—This frog is far less aquatic than most of the others, preferring to spend its life among fallen leaves of the forest. It repairs to the water only in the breeding

season, which is the only time when it croaks. It is never found in the water during the remainder of the season. It is not often seen, but occasionally occurs in large numbers. They are said to be very skillful in hiding, and the close resemblance of their colors to the dead leaves and grass surrounding them renders it very difficult to find them. Prof. S. F. Baird was the first to observe that the tadpoles of this frog are carnivorous. (Hay.)

Family Engystomatidae.

No parotoids. Tympanum concealed. Fingers and toes not expanded at their tips, the former without, the latter with or without, webs. No teeth. Hearing apparatus fully developed. Prefrontals fully developed, in contact with each other, and with the parietofrontals. No overlapping sternal cartilages. Clavicles and precoracoids sometimes wanting. Transverse processes of sacrum dilated.

It is represented in North America by the single genus Engystoma. (Garman.)

Genus engystoma.

Head small, pointed, continuous with the body; mouth-cleft small; tongue free behind, elliptical, entire. Limbs stout and rather short. Eustachian ossicle very small. Males with an internal, subgular vocal sac. (Garman.)

35. Engystoma carolinense Holbrook. Nebulous Toad. Carolina Toad.

Engystoma olivaceum.

Description.—Head short, pointed; body thick, nearly oval; skin smooth. A fold across the head behind the eyes, which, however, is often wanting in alcoholic specimens. Toes quite free with blunt tips and distinct subarticular tubercles; a very small inner metatarsal tubercle. With the hind limb carried forward along the body, the tibiotarsal articulation reaches the shoulder in the female, and a little beyond in the male.

Color.—Color above olive-brown or gray, marked and spotted with dusky; below pale yellowish, closely marbled with purplish, but more yellowish posteriorly on the abdomen and under side of the femora. Two wide, poorly defined pale bands begin at the fold of the skin behind the eyes and pass backward and slightly downward to the insertion

of the femora; they are bordered above by a sinuous band of interrupted elongate dark spots, and below by a wider continuous dark band, which in front passes immediately over the fore legs, through the eye and around the snout, where it unites with its fellow of the opposite side. Two dark bands cross the tibia. The throat of adult males is bluish black. The colors vary with age and, to some extent also, at the will of the animal. Older examples are darker, and the markings are in them more obscure. The characteristic markings are consequently more apparent on medium-sized specimens because of the paler color and consequent greater contrast between it and the dark marks. A black spot over the vent. (Garman.)

Size.—Length of head and body 36 mm.; from tip of snout to axilla 13 mm.; femur 13 mm.; tibia 12 mm.; tarsus and fourth toe together 20 mm.

Habitat.—South Carolina, Georgia, Florida, westward to Texas, north into Missouri and southern Illinois. Missouri localities:—St. Louis and Butler Counties.

Habits.—*Engystoma carolinense* looks very different from any of our typical frogs and toads. Its tiny head with dark bead-like eyes seems wholly out of proportion to its relatively large, squat body. It resembles more a little turtle, particularly when in the specimen the fold of the skin behind the eyes is present. The Carolina Toad is very quick, even with its short legs, it proceeds by short rapidly given jumps. Generally it is found under logs, with only its head sticking out of the ground, in marshy places. In spring when mating it goes to the water in stagnant pools. When floating in the water, only the tip of its pointed head is out of the water, so that on approach of danger it can disappear beneath without leaving a ripple on the surface. Its habits are entirely nocturnal. Its call is said to sound like the noise made by an electric buzzer. When kept in captivity the male sings almost continually. A throat pouch which extends backward to a line between the insertion of the arms, is inflated during the call.

In my early collecting days I discovered three in one day under rocks on the southern exposure of a hill-side at Cliff Cave, St. Louis County. I have never again

found any at that place. At Poplar Bluff, Butler County, it is quite plentiful.

Dates of capture.—Apr. 26; May 15, 28; Sept. 5.

Class **Reptilia.**

Exoskeleton in the form of horny scales or bony plates. One occipital condyle. Mandible present, each ramus of several bones. Vertebrae without terminal epiphyses. Generally no diaphragm (an incomplete diaphragm is present in crocodiles). Respiration always by means of lungs, sometimes aided by the walls of the pharynx. Heart generally with three, sometimes with four, chambers. Two aortic arches. Blood not warm; red corpuscles nucleated. Alimentary canal terminating in a cloaca. Oviparous or ovoviviparous. (Garman.)

The existing reptiles are divided by Dr. H. F. Osborne into two sub-classes, *Diapsida* and *Synapsida.* To the latter belongs only one existing order, viz., the turtles (*Testudinata*), which are characterized by having the scapular arch internal to the ribs, while in the three existing orders of the *Diapsida* it is external. These orders are: *Crocodilini* (also called *Loricata* or *Emydosauria*), characterized by two-headed ribs; *Rhynchocephalia,* represented by a single surviving genus in New Zealand (*Sphenodon*), superficially resembling a lizard, but distinguished from the next order by having, among other characters, the quadrate bone immovably fixed to the adjacent cranial elements by suture, while in the *Squamata,* embracing snakes and lizards, it is loosely articulated with the cranium at the proximal end; the last two orders have one-headed ribs. (Stejneger.)

Subclass **Diapsida.**

Primarily with double or separated temporal arches.

Order SQUAMATA.

The order *Squamata* consists of three sub-orders—the chameleons (*Rhiptoglossi*), the lizards (*Sauria*), and the snakes (*Serpentes*). Of these only the two latter orders are represented in Missouri.

The anatomical characters which distinguish them consist chiefly in the separate condition of the rami of the lower jaw in the snakes, while they are solidly united in the lizards; in the total absence even of vestiges of a pectoral arch in the snakes; and in the closing of the brain case anteriorly in the latter. There are no external characters which will in all cases separate a snake from a limbless lizard, except that in the latter the tongue is not retractile into a basal sheath, while in most cases they possess distinct eyelids and ear-openings, both wanting in the snakes. (Stejneger.)

Suborder SAURIA.

Body elongated and covered with numerous small imbricated scales. Four limbs (rarely wanting). Shoulder girdle always present. Eyelids and external organs of hearing present. Jaws with teeth set in a continuous groove; jaws not dilatable. Heart with three chambers. Urinary bladder present. Oviparous, with a few exceptions. (Garman.)

Key to the Families Represented in Missouri.

Tongue not bifid. Legs four. Scales imbricated, carinated above. A fold of the skin on each side of the neck. Proximal end of clavicle simple. *Iguanidae.*

Tongue deeply bifid, with an ensheathing base. Legs wanting, or with a pair of rudimentary hind legs. Body serpenti-form. A lateral longitudinal groove. Proximal end of clavicle simple. *Anguidae.*

Tongue bifid, but with no ensheathing base. Legs four. Two transverse subgular folds of skin. Scales granular above, large below. Premaxillary single. Clavicle dilated at proximal end. *Teiidae.*

Tongue notched at the tip. Legs four. No transverse subgular folds. Scales smooth and about uniform in size above and below. Premaxillary double. Proximal end of clavicle simple. *Scincidae.*

Family Iguanidae.

Tongue short, thick, fleshy, but slightly free in front, scarcely bifid. Teeth attached to the inner face of the jaws, pleurodont. Femoral pores present or absent. Premaxillary single. Clavicle with simple proximal ends. Mesosternum anchor-shaped. A xiphisternal fontanel present. Abdominal ribs generally wanting. (Garman.)

Key to Genera of Iguanidae.

Ear without strong denticulation and neck without spinose tubercles. Superciliaries imbricate. Tail long and tapering. *Crotaphytus.*

No complete transverse gular fold. *Sceloporus.*

Head with large spines posteriorly. *Phrynosoma.*

Genus crotaphytus.

Head and body somewhat depressed and much shorter than the tapering tail. All of the head plates are small. The labials not imbricated. The ear-opening is large, without strong denticulation. Dorsal scales small and nearly uniform. Long series of femoral pores and one or more transverse gular folds are present. There are no spinose tubercles on the neck. The superciliaries are imbricated. Males with enlarged post-anal plates.

36. Crotaphytus collaris Say. Collared Lizard. Bull Lizard. Mountain Boomer.

Agama collaris, Liosaurus collaris.

Description.—Head very broad, its width fully equal to the distance from snout to ear. The head is much depressed and very distinct from the neck, especially in the males. Nostrils large, turned upwards and outwards, a little nearer to the end of the snout than the orbit. Ear-opening large, vertically reniform. Scales on the snout a little enlarged, irregular, convex; a series of enlarged supraorbital scales, forming a letter X between the orbits; the two middle scales fused together, forming there only one row. Tongue narrow, slightly notched at the tip, where it is free at the sides. Palatine teeth. Cheek teeth compressed with three-lobed crown behind; conical anteriorly. The bases apparently in a shallow groove.

Supraocular scales small; back of the head with small granules. Labials very small. A series of enlarged infra-orbital scales, very variable in number and size; the median one sometimes much elongate, owing to the fusion of two, or three scales. Throat covered with small granules, which are slightly enlarged and flat in front of the gular fold. Sides of neck strongly plicate. Dorsal scales uniform, small, juxtaposed granules; ventral scales larger, flat, hexagonal. Limbs long; hind limb reaches to the eye or to the tip of the snout; digits rather long. Seventeen to twenty femoral pores on each side. Tail slender, cylindrical, nearly twice as long as head and body, covered with uniform, small, smooth or feebly keeled scales.

Color.—Upper parts of a variable shade of dark green or bluish; the thigh, back, and sides marked pretty regularly and closely with round

or oblong light spots, which on the lower part of the back and on the tail above exhibit a tendency to transverse light bands. The upper part and sides of the head, the tibia and tail marked with similar dark spots. Two half rings of black extending across the back between the insertion of the legs. Fore legs each bordered with yellowish. Under parts yellowish white, tinged in some specimens with greenish, especially between the fore legs. Chin and throat green or blue (sometimes nearly black) and quite regularly reticulated with yellowish. In life, the light spots, especially in young specimens, are of various shades of red, orange, yellow and white. In the young and sometimes quite large specimens the light dorsal spots exhibit a great tendency to form transverse bands more or less continuous.

Size.—From tip of snout to end of tail 290 mm.; head and body 96 mm.; fore limb 43 mm.; hind limb 80 mm.; tail 200 mm.; head 28 mm.; width of head 25 mm.

Habitat.—Kansas, Oklahoma, Missouri, Arkansas, Texas, and New Mexico. Missouri localities: Jefferson, Washington, St. François, Madison, Iron, Ozark, Stone, Miller, and Phelps Counties.

Habits.—Mr. John R. Fordyce of Little Rock, Ark., wrote me, under date of July 14th, the following observations which he made on a specimen which came from Mount Magazine, about 110 miles west of Little Rock: "The Mountain Boomer is a good jumper, and can catch grasshoppers and other flying insects by jumping from a foot to eighteen inches in the air after them. I put a small Six-lined Lizard in his cage and he swallowed him whole in two or three gulps. He seems very ferocious and jumps at your hand with his large mouth wide open. The natives call them Mountain Boomers and say he is deadly poison."

The Collared Lizard runs very swiftly, carrying the tail over his back, and he is surely the most pugnacious of our lizards. To catch one, when on a rock or open space, is a very easy matter for two persons. One stands still and watches the lizard, which will keep an eye on him, and the other person sneaks around the lizard and grabs him from behind. His bite does not amount to anything.

Dates of capture.—May 2, 21; July 14; Sept. 1.

Genus SCELOPORUS.

Head short, convex above. Upper head scales enlarged, occipital very large. Nostrils near the margin of the snout, opening in a single plate. A short fold on each side of the neck. The dorsal scales are large, nearly equal sized, mucronate and strongly imbricate. The ear-opening is large with a well developed anterior denticulation. The labials are juxtaposed. The scales of the tail carinated; those of the belly smooth. Femoral pores numerous. Digits with keeled lamellae inferiorly.

37. SCELOPORUS UNDULATUS Bosc. Fence Lizard. Alligator Lizard.

Lacerta undulata, Stellio undulatus, Agama undulata, Lacerta fasciata, Lacerta hyacinthina, Uromastix undulatus, Tropidolepis undulatus, Sceloporus longipes.

Description.—Cephalic plates smooth or lengthwise rugose, especially anteriorly, and laterally. Supraorbital region with one crescentic series of five or six large, transverse plates, embracing a short series of three or four additional outer and inner series of smaller plates in its concavity. Back of head with three plates. The middle or occipital larger than the outer ones, the parietals; the former with a central transluscent spot. Two frontal plates. A single nasal plate with the nostril opening in its posterior part.

Anterior border of ear-opening denticulated with three or more scales. Three rows of small supralabials. On the side of the neck, behind the ear is a fold of skin overlapping a vertical impression, which is lined with minute scales. Scales above, large, sharply carinate and mucronate, many of them with notches on each side of the apex. About forty-five scales in a row from the occipital to a point opposite the vent. Lateral scales smaller than dorsals. The belly scales smooth and strongly emarginated. Femoral pores about fourteen. All the scales on the tail strongly carinated and verticillated. A curved linear impression behind the vent. Males with enlarged post anal scales.

Color.—Color above grayish brown, with a series of transverse undulating black bars on each side of the back. Tail and legs above barred with black. All the bars bordered posteriorly with pale. A narrow black line extends from the eye backwards over the ear and fore leg, and may terminate behind the latter or pass into a brown band which continues along the side of the abdomen. This last is often obscure or wanting. A narrow black line crosses the head from one superciliary ridge to the other. Color beneath grayish white or bluish; in females and young with no, or few, green or blue scales on the throat, and with the throat, sides, and ventral surfaces of the femora speckled with black, generally with a short, dark median band before the vent;

in males with most of the throat and a large elongate patch on each side of the abdomen of a metallic blue or green color. (Garman.)

One of my specimens from St. Louis County shows a dorso-lateral, dark brown, nearly continuous band; and on the sides from four to five vertical bars of the same color.

Size.—Length from tip of snout to vent 68 mm.; tail 90 mm. (Female).

Habitat.—The whole eastern United States from New Jersey to Florida, west to Kansas and Texas. Abundant in Missouri everywhere.

Habits.—These little lizards are found under decaying trees and under stones. During the day they bask in the sun on old fences—hence their common name of "Fence Lizards." When surprised they will attempt to climb a tree, and because of their highly protective color, resembling very much the rough gray bark on which they rest, may escape. Dr. C. C. Abbott of New Jersey came to the conclusion that their vision is not acute, while their hearing is sharp. In endeavoring to catch flies they often missed their aim, although the insects were within easy reach. Some of Dr. Abbott's experiments tend to show that the so-called "pineal eye" is yet sensitive to the light. Their food consists of flies, ants, small spiders and the like. Any warm day these lizards may be found sunning themselves.

Dates of capture.—Apr. 22; July 24; Sept. 1, 5; Oct. 3; Nov. 7, 18.

Genus PHRYNOSOMA.

The body is very broad, greatly depressed, without dorsal crest, but usually with a lateral fringe. The head is covered with small subequal scales and bears bony spines on the occipital and temporal regions. The tympanum is either distinct or partially or entirely scaled. The dorsal scales are very irregular in size and shape. Series of femoral pores and one or more transverse gular folds are present. Tail short. Males with enlarged post-anal plates.

38. Phrynosoma cornutum Harlan. Horned Lizard. Horned Toad.

Agama cornuta, Tapaya cornuta, Tropidogaster cornutus, Tropidogaster bufonium, Lacerte tapayaxin, Phrynosoma bufonium, Phrynosoma harlanii, Phrynosoma orbiculare, Phrynosoma planiceps, Phrynosoma cornutum.

Description.—Head short, muzzle descending steeply in profile. Nostrils directed forward and separated from the scales of the canthus rostralis by a single scale. Posterior superciliary angle produced into a short horn. Temporal region expanded, supporting three horns, the anterior short, the median equal to or longer than the posterior one; all directed outward and a little upward. Occipital horns moderate, acute, well separated, slightly divergent, and directed more than 45 degrees upward. Scales of front and vertex rugose. A row of three or four conic scales anterior to the occipitals, and one posterior median occipital not very long. Infralabials prominent and acute posteriorly, the last equal to or longer than the first temporal. Gular scales keeled and a row of enlarged ones on each side. Two groups of spines on each side of the neck. Large scales on humerus, extending across the cavicular region. Several gular folds, irregular.

Back with some very large erect spinose tubercles, which form a series of three or four on each side of the vertebral line. Two lateral series of spines, the upper the larger. Pectoral and ventral scales more or less distinctly keeled. Femoral pores in males four to twelve, not extending on the prae-anal region, sometimes very indistinct. No enlarged post anal scales. Superior surface of humerus and cubitus covered with large keeled and mucronate scales. Femur and tibia covered above with smaller keeled scales, intermixed with a few large spinose ones. Tail with a marginal row of spines on the basal half and intermixed with larger scales on the superior surface. Scales on the inferior side of limbs and tail, except the femur, keeled, the tail most strongly. (Cope.)

Color.—Grayish or brownish above with a more or less marked light dorsal streak, and dark brown spots at the base of the larger dorsal spines; a large dark brown spot on each side of the nape; two cross streaks between the superciliary ridges, a band from the eye to the angle of the mouth, and from the eye to the middle temporal spine, dark brown. Lower surface yellowish, uniform, or with some brownish spots.

Size.—From tip of snout to vent 110 mm.; from vent to end of tail 46 mm.

Habitat.—The range of the Horned Toad extends from Chihuahua, Mexico, north through Texas, southern Kan-

sas and Missouri. I have never found a specimen in Missouri, but E. D. Cope in the Report of the U. S. National Museum for 1898 reports two specimens, Nos. 17,397-9 of the Smithsonian Collection, from southwest Missouri, collected by C. W. Richmond.

Habits.—This species loves dry places and sunshine. When at rest it is hard to see on account of its protective coloring, but easily caught when it moves and catches your eye. It is perfectly harmless and often kept as a pet. If they will eat they may be kept in confinement for a long time. Most of the time, however, they starve themselves to death. This is one of the species of Horned Toads that squirts blood out of the corner of its eye. In my collecting in Texas, New Mexico, and Arizona I several times captured *Phrynosomas* that squirted blood at my hand or face. O. P. Hay in Volume 15 of the Proceedings of the U. S. National Museum published an article "On the Ejection of Blood from the Eyes of Horned Toads," where he gives the following account of the blood squirting habit of these lizards: "In examining the animal that a student had brought me, I took occasion to turn him on his back, using a lead pencil for the purpose. The animal resented this treatment and showed considerable anger, opening his mouth and puffing up his body. Irritating the animal still more, he grew more and more enraged, until finally blood spurted from just above his eye, which was fired at least a foot from the animal, as several spots struck my arm considerably above my wrist. After spurting the blood the animal became limp and collapsed, and remained in a stupor for some time, and, when handled, behaved as if dead. After a time, possibly not over five or six minutes, certainly not over ten, the animal revived and commenced to run about the table. Wishing to know if he would repeat the operation, I commenced to irritate him again in the same manner. After becoming enraged again the animal soon went through the same process, ejecting blood from the same

eye as before. He then fell into a similar stupor and remained about the same length of time, after which he revived. No amount of irritation could produce a third discharge, although the animal showed some anger."

My friend, Mr. John K. Strecker, Jr., of Waco, Texas, published in the Proceedings of the Biological Society of Washington, Vol. 20, an article entitled "Notes on the Breeding Habits of Phrynosoma cornutum in Texas." This Horned Toad is oviparous, he states, and gives the following account of its breeding habits: "The usual site selected for the nesting burrows is the base of a slanting bank of earth or sand. The hole seldom goes straight down, but is usually dug at an angle of about 45 degrees. The animal's fore-feet are used in digging, while the hind-feet assist in pushing the earth out of the burrow. As soon as one layer of eggs has been deposited, the lizard fills in ground over them and is then ready for the next lot. In one nest examined by me, the eggs were arranged in four layers of six each. It is really marvelous how hard and firm the earth is packed into the burrows. The period of incubation is about from thirty-five to forty days. The breeding season extends in Texas from the middle of April into the latter part of July. When first hatched the young are smooth and tender, but in a short time are very active in their movements, and fully able to take care of themselves. They do not receive any care from the mother, who probably never returns to the spot where she buries the eggs."

Family Anguidae.

Legs wanting or two rudimentary posterior legs present. Body long and serpentiform, with lateral longitudinal grooves. Head pyramidal. Tongue bifid, extensile, with squamiform papillae. Teeth placed on the inside of the jaws and projecting inwards. (Garman.)

Genus OPHISAURUS.

Legs wanting. Ear-opening present, small. Eyelids well developed. A deep groove along each side of the abdomen. Two longitudinal

series of teeth on the roof of the mouth borne on the pterygoids and palatines. Several supranasals. Nostrils lateral, opening through a single plate. Sternal bones represented by rudimentary cartilages; clavicles not meeting at the middle line. Pelvis rudimentary and cartilaginous, the cartilages of opposite sides not meeting at the middle line, each bearing a minute cartilage representing femora. (Garman.)

39. Ophisaurus ventralis Linn. Glass Snake. Joint Snake.

Anguis ventralis, Chamaesaura ventralis, Hyalinus ventralis, Ophisaurus punctatus, Ophisaurus striatulus, Ophisaurus lineatus, Caecilia maculata, Opheosaurus ventralis.

Description.—Head continuous with the body, compressed forwards and pointed. Two series of superciliary plates. Frontal large, widest behind. Two small frontoparietals. Two large parietals and a pentagonal interparietal with a small whitish spot, the "pineal eye." Two prefrontals. Internasal large, as broad, as long. Seven supranasals. Nasal plate small, perforated by the nostril. Rostral slightly wider than high. Eleven supralabials, the ninth and tenth largest. Marginal series of infralabials elongate and narrow.

Ears a short, longitudinal slit of varying size, in line with the mouth and lateral groove. Palatine teeth present. The pterygoid teeth in three to five longitudinal series. Teeth all conical. Body long and slender. Scales equal in size above and below, those on the posterior part of the body and on tail with a slight median ridge forming obtuse carinae. A deep groove extending from a short distance behind the ear along the sides of the abdomen to the vent. Sixteen rows of dorsal scales.. Ten rows of ventral scales. Seven or eight preanal scales a little larger than the abdominals.

Garman gives the arrangement of the sternal and pelvic bones as follows: "The rudimentary sternal bones are imbedded in the muscles a short distance behind the head. The sternum is a thin, transversely elongate plate of cartilage, and lies behind the other bones of the arch. The scapula is largely, perhaps wholly, bone. The supra-scapula is well developed and is cartilaginous. The coracoid is large, transversely placed, and meets its fellow of the opposite side; it is also cartilaginous. The clavicle is a slender, curved bone, which is attached at its outer extremity to the ventral surface of the supra-scapula.

"The pelvic bones consist of a rather long ilium, attached to the transverse process of the fifty-seventh vertebra, and a flattened bone, supposed to represent the ischium and pubis combined, at its free extremity. In a small acetabulum in the surface of the latter fits a minute cylindrical femur. The bones are fully ossified. Those of the two sides are separated by a considerable interval. They are imbedded in muscle slightly in front of the vent. The rudiments are probably quite variable."

Color.—Color above clay yellow, or brown, or greenish olive, with a median longitudinal stripe of brown, and on each side above the lateral grooves a wide black or brown stripe including three narrow whitish lines. On the side of the abdomen beneath the lateral grooves are two narrow dark stripes. Beneath yellowish white.

In some specimens the color above is very dark, greenish olive; posterior border (in the corners) of each scale, with two bluish or greenish white rounded spots. The central line of each series, especially where transversed by the ridge, is darker than the ground color, and not spotted; the whole pattern may be said to form transverse bands over the back.

Size.—From point of head to vent 247 mm.; from vent to end of tail 455 mm.

Habitat.—This species is found from Florida, west to Texas, north to Kansas, Missouri, Illinois, Indiana, and Wisconsin. Missouri localities: St. Louis, Jefferson, Oregon, Howell, Stone, Jasper, Johnson, Jackson, Warren, St. François and Phelps Counties.

Habits.—The Glass Snake is rather scarce. During twenty-five years of collecting in the state I have only caught two myself. These I found under rocks. In Jefferson County the farmers come across them oftener when breaking new ground. Specimens with stub-tails are mostly found.

On account of the serpent-like form of this lizard, it is almost universally regarded as a snake. It may be distinguished from the serpents by the little distensible mouth, the firm union of the sides of the lower jaws at their symphysis, by the possession of eyelids, and by the rows of small scales covering the belly. The facility with which the whole animal appears to break up into short pieces has given rise to the popular name "Glass Snake" or "Joint Snake." The popular belief is that these pieces have the power of reuniting themselves, so that the reptile is thoroughly reconstructed and as sound as ever. Concerning these matters there has been a great amount of discussion in the newspapers and even in some scientific journals. As regards the liability of the animal

to break up into different lengths on being struck or roughly handled, there is no doubt that the popular notion is correct. Two-thirds or more of the Glass Snake is tail. Many of our lizards drop their tails on being caught to free themselves. The tail thus lost is reproduced. The Glass Snake when struck or captured may sunder its tail into a number of wriggling pieces, and while the astonished observer stands viewing the wreck, the head and body may skip away to a place of safety. In order that all these pieces might unite again to form the remodeled lizard, they would have to be fitted together in their proper order, and with the ends turned in the proper direction; the half dozen or more conical muscles which project from the ends of the pieces would have to be interdigitated accurately; the nerves and blood vessels would need to come into juxtaposition; and then all the torn surfaces unite by "immediate union" so quickly and effectively that the animal can go about its business. This clearly shows the fallacy of the popular motion. (Hay.)

The Joint Snake is mostly found in dry meadows, on hilly sides with southern exposure. It feeds on ground spiders, grasshoppers, crickets, cock-roaches, coleopterous and lepidopterous larvae, and small snails. Sometimes the large intestine is packed with fragments of coleoptera. In confinement it feeds readily, taking even insects from the hand of its master.

Dr. George Engelmann sent three specimens to the Smithsonian Collection, No. 3193, and two, No. 5131.

Dates of capture.—June 21; Aug. 7; Sept. 15.

Family Teiidae.

Tongue long, bifid, with squamiform papillae. Teeth solid, pleurodont. Head pyramidal, with large, regularly disposed plates above. One pair of supranasal plates. Nostril opening in the midst of a plate, or between two plates. Scales of the back granulate or carinate; scales on abdomen large. A xiphisternal fontanel; premaxillary single; clavicles dilated proximally; mesosternum cross-shaped. (Garman.)

Genus CNEMIDOPHORUS.

With two subgular folds. Tongue with no sheath, free behind. Maxillary teeth compressed, the posterior teeth tri-cuspid. Femoral pores present. Scales granulate above, transversely elongate and quadrangular on the belly. Digits 5-5. (Garman.)

40. CNEMIDOPHORUS SEXLINEATUS Linn. Swift. Six-lined Lizard.

Lacerta sexlineata, Ameiva sexlineata, Lacertus griseus.

Description.—Head rather small, compressed in front of the eyes and pointed. Rostral produced backwards and acutely angled between the nasals, which are large and touch on the middle line. A large frontal; on each side of which, over the eye, are four supraoculars, the two middle ones the largest. One loral on each side. Five or six supraparietals, which are followed posteriorly by three plates of nearly the same size. Two series of plates on the lower jaw, the inferior and the largest consisting of five plates, the two anterior ones being in contact with each other. Ear-opening vertical, oblong, exposing the tympanum. Gular folds two, the posterior with large scales in front.

Upper surface of the lower limbs with large scales. Front of thighs and under surface of the legs with enlarged scales. Scales of the upper surface of the body small, those of the belly large and rectangular, arranged in eight longitudinal rows, with about 33 to 36 transverse rows. Vent with three enlarged scales in front. Femora with a ridge bearing sixteen pores. Tail round, covered with large, verticillated, carinated scales above, smooth underneath.

Color.—Color above brownish gray, with three narrow yellow longitudinal lines on each side with black spaces between them. Head brown or blue-gray. Legs brown. Under parts bluish white.

Size.—Length of head and body to vent 80 mm.; tail beyond vent 146 mm.; total length 226 mm.

Habitat.—Eastern North America from Maryland to Florida, west to Nebraska, south to Texas. Missouri localities: St. Louis, Jefferson, Taney, Stone, Jackson, Johnson, Randolph, Warren and Pike Counties.

Habits.—This lizard runs with great swiftness. It can hardly be followed with the eye, and is, therefore, very difficult to secure. The best way is to shoot it with fine shot. Early in the morning, when under rocks and not yet thoroughly warmed, it is easily captured. It never resorts to trees, but trusts to its swiftness and skill in

dodging from one covert to another to escape its pursuers. It occurs in dry sandy regions, where it may be seen by roadsides among the shrubbery, or running along the lower rails of fences. They are generally found in pairs, but nowhere abundantly, at least not in Missouri. They live from insects; and in turn seem to be welcome prey for snakes.

Dates of capture.—May 2, 20; July 14; Sept. 5.

Family Scincidae.

Tongue thin, flat, moderately long, free and slightly notched in front; covered with overlapping scale-like papillae. Teeth pleurodont. Head with symmetrical plates. Nostrils generally in one plate. Basal portion of scales ossified. Praemaxillae double.

Key to the Genera in Missouri.

With two supranasals. Lower eyelid scaly. Anterior margin of ear-opening with several projecting scales. Palate with two slits, one from each nostril. *Eumeces.*

No supranasals. Lower eyelid with a transparent central part. Ear-opening with no projecting scales. Palate cleft by a single median slit. *Leiolopisma.*

Genus eumeces.

Limbs well developed. Nostril pierced in the nasal plate. Eyelids with scales. Tympanic disk distinct, deeply sunken. Maxillary teeth with conical or rounded crowns. Pterygoid teeth present. Palatine not meeting in the median line; palate therefore with two clefts, one from each nostril. (Hay.)

41. Eumeces quinquelineatus Linnaeus. Blue-tailed Lizard. Red-headed Lizard. Scorpion.

Eumeces fasciatus, Lacerta quinquelineata, Lacerta fasciata, Lacerta tristata, Scincus laticeps, Scincus quinquelineatus, Scincus tristatus, Scincus erythrocephalus, Scincus bicolor, Scincus americanus, Tiliqua quinquelineata, Tiliqua bicolor, Plestiodon laticeps, Plestiodon quinquelineatum, Scincus fasciatus, Eumeces laticeps, Mabuya quinquelineata, Euprepis quinquelineata et fasciata, Euprepis decatesby, Plestiodon erythrocephalus, Tiliqua erythrocephala, Lacerta cauda caerulea.

Description.—Head short, obtuse. Cheeks strongly swollen in old full grown specimens. Nasals small, the anterior pierced by the nostril and followed by a small postnasal, which forms a suture with the first

labial. Two lorals, the anterior one forming a suture with the fronto-nasal. Two supra-nasals. A single internasal and two prefrontals. Frontal and parietals are the largest of the head plates. One frontal. Four supra-oculars, the three anterior in contact with the frontal. Behind the frontal on the median line is the interparietal, in which a faint whitish spot indicates the position of the "pineal eye." Nine supra-labials, the eighth the largest; six only reaching to the orbit. Six infra-labials, the sixth the largest. Ear-opening large, somewhat elongated vertically, in young examples with a few projecting scales at its anterior margin. Body moderately slender, tail long and tapering. Scales smooth, about equal in size above and below, median row beneath the tail largest and transversely elongate. Twenty-eight to thirty scales in a transverse row around the body, midway between the fore and hind legs.

Color.—Young and middle aged individuals are nearly black above, with five yellow lines running from head to middle of tail. The median line bifurcates on top of the head. The extremity of the tail is often bright blue. The abdomen is bluish white. As the animal grows older the stripes become obscure, the general color fades to olive or brownish, and the head in the males becomes bright red.

In very old specimens the color of the back becomes nearly uniform grayish brown. The cheeks are then swollen, and the males are red on top of the head. Many of the old females retain the stripes on the back but have no swollen cheeks.

The different color phases were formerly described under three different names.

Size.—An old male from Butler County, Mo., measured 106 mm. from head to vent, and from vent to tip of tail 125 mm. Total length 231 mm.

Habitat.—This species is found in the eastern part of North America from Canada to the Gulf of Mexico. Missouri localities: St. Louis, Jefferson, Washington, Iron, Stoddard, Butler, Shannon, Dunklin, Oregon, Ozark, Stone, McDonald, Jackson, Miller, Crawford, St. Charles, Pike, Montgomery, and Randolph Counties.

Habits.—This species is found generally under rocks and rotten logs. When out of its retreat, the Scorpion Lizard runs equally well on the ground or on trunks of trees. When captured it tries to bite, but as far as I have experienced does no harm. If grabbed by the tail, it turns quickly, twisting it from the body and leaving it as a wriggling souvenir, losing no time in finding a place of

shelter. Specimen No. 5 of my collection, a very large adult female without wide cheeks and the regular stripes on the back, I captured running up the trunk of a hollow tree. I put it in my vivarium, where, after a few days, I found her under a rock coiled around eight eggs, which she would only leave when disturbed. In due time I found eight nice little blue tails, each about 1¼ inches long. A few years later I found at Cliff Cave under a rock another female—a younger specimen—again coiled around eggs. This is the only female lizard that behaves thus, and the question in my mind is whether the body heat of these so-called cold-blooded animals has any influence on the hatching of the eggs.

42. Eumeces anthracinus Baird. Coal Skink.

Plestiodon anthracinus.

Description.—Head and body depressed, quadrangular; in section rather slender. Tail cylindrical, attenuated, one and one-half times the head and body. Supranasals, internasal, and prefrontal rhomboid; the former small and more transverse than the rest. One prefrenal equal to the supra-nasal, half as long as and higher than the pentagonal loral, extending upward to contact with the internasal. Upper labials, six or seven. One large transverse pentagonal mental plate in the end of the chin, behind the tip, instead of the two of *E. quinquelineatus.* Hind leg applied twice forward reaching about to middle of neck. Scales of body in twenty-four longitudinal rows, smooth. (Cope.)

Color.—Four narrow yellow lines, two on each side of the broad longitudinal lateral black band. This band begins at the nostril and passes through the eye to the vent. Tail dark blue above, beneath lighter. Top of legs and feet black, lighter below. Old specimens have the top of the head tinged with red.

Size.—Head and body to vent 56 mm.; from vent to end of tail 101 mm. Total length 157 mm.

Habitat.—The Coal Lizard is reported as abundant in the Alleghany region from Pennsylvania southward. It also occurs in Texas, Arkansas, and Missouri. Missouri localities: Cope in his Crocodiles, Lizards and Snakes of North America reports No. 3123 of the Smithsonian Collection from Laclede County, collected by J. H. Clark.

John H. Frick, Warrenton, reports this lizard from Warren and Franklin Counties. I have collected four specimens in Jefferson County.

Habits.—This species is found under rocks and logs on slopes with southern exposure, but not as abundantly as *E. quinquelineatus.* Its food consists of insects.

Dates of capture.—Apr. 7, 27; July 24.

Genus LEIOLOPISMA.

Body fusiform, cylindrical. Head short, pyramidal. No supranasal plates. Limbs well developed. Nostrils pierced in the nasal plate. Eyelids well developed, movable, lower eyelid with a transparent disk. Tympanum not covered with integument. Palatine bones in contact on the median line of the palate. Scales smooth.

43. LEIOLOPISMA LATERALE Say. Ground Lizard.

Liolepisma laterale, Lygosoma lateralis, Oligosoma gemmingerii, Oligosoma laterale, Mocoa lateralis, Tiliqua lateralis, Scincus lateralis, Lygosoma laterale.

Description.—Rostral broadly in contact with fronto-nasal, the portion visible from above much smaller than the latter shield; no supranasals; nostril in the center of a single shield; no post-nasal; fronto-nasal, in contact with frontal, broader than long; prefrontals not in contact; anterior loreal in touch with first supra-labial, in contact with second supralabial, fronto-parietal and prefrontals; frontal much longer than its distance from tip of snout, shorter than length of fronto-parietals and interparietal together, very wide in front, tapering nearly to a point behind, in contact with first and second supraoculars; four supraoculars, second largest; fronto-parietals long and narrow, longer than interparietal, which is shaped like the frontal but not so long; parietals long and narrow, as long as frontal, in contact behind interparietal; four pairs of nuchals, first not in contact; lower eyelid granular with a small, transparent disk; seven supralabials, fifth under the eye, sixth largest; a very large upper temporal, fan-shaped with the apex forward, in contact with the entire outer edge of the parietal; ear-opening large, as large as eye, without lobules along the anterior border; a single unpaired pentagonal shield behind the mental; 28 smooth scales around the middle of the body, those on the sides but slightly smaller; two large preanal plates with a small one on each side; hind leg contained about three times in distance from snout to vent; fore and hind legs fail to meet when appressed along the side; 16 lamellae under longest

toe; tail cylindric, pointed, with transversely widened plates underneath. (Stejneger.)

Color.—Above uniform olive brown; a blackish-brown line from nostril through eye, widening on tympanic region and extending above the ear-opening backward along sides above fore and hind legs to side of tail as a broad dark-brown band above and below narrowly and indistinctly edged with whitish; on the flanks below this edge a paler brown, more indistinct band; underside pale. (Stejneger.)

Size.—Head and body to vent 48 mm.; from vent to end of tail 78 mm. Whole length 126 mm. Hind leg 16 mm.

Habitat.—On the supposition that the American and Asiatic specimens really are identical, the present species has a very unique distribution. In North America it is known to inhabit the lower Austral life zone east of the Rocky Mountains, and is not found west of the latter at all. In Asia it occurs over a large area in China along the coast from near Ningpo to Canton, in the interior to the province of Szechuen, or to the extreme west end of the province of Yunnan, while northward it extends its range to the neighborhood of Peking. (From Stejneger's Herpetology of Japan and Adjacent Territory.)

In the United States it is found from Florida west to Texas, North Carolina, Southern Indiana, Illinois, Missouri and Kansas. The specimen No. 18,012 of the Smithsonian Collection was caught at Cliff Cave, on the Iron Mountain Railway, eleven and one-half miles south of St. Louis. Missouri localities: St. Louis, Jefferson, Shannon, Pemiscot, Dunklin, Butler, Oregon, Stone, Jackson, Phelps, and Crawford Counties. So far I have never heard of one being observed north of the Missouri River. The farther south of St. Louis one goes the more abundantly it is found.

Habits.—The Ground Lizard is found under rocks, rotten logs, leaves and loose bark of fallen trees. When uncovered they display considerable agility, half running, half wriggling away in a series of rapid, lateral undulations to disappear among dead leaves or to bur-

row their way into mould or leaves. Few specimens are actually seen abroad and these are exceedingly timid, darting into the leaves or hiding place at the slightest disturbance. As they pass most of their time in hiding they are poor subjects for observation, only coming out after sunset in search of small insects and worms. I have never seen one ascend a tree.

Dates of capture.—Apr. 4, 25; May 5, 10; July 4; Sept. 5; Nov. 7.

Suborder SERPENTES.

Body greatly elongated and covered with horny imbricated (in a few cases granular and not imbricated) scales. Limbs wanting (rudiments of hind limbs present in Boas, Pythons, and a few others). Shoulder girdle never present. Eyelids and external organs of hearing wanting. Mouth very dilatable, the bones of the jaw being loosely articulated. No urinary bladder. Oviparous or ovoviviparous. (Garman.)

Because of the superstitions associated with them, serpents possess a peculiar interest for most people. The almost universal dread in which they are held, has probably been acquired in the majority of cases. Children that have been raised and shown the snakes, without filling their minds with all kinds of terrible stories, are not afraid of them and handle them as they would a pet cat or dog. This experience I made with my own children and grandchildren. Whenever I brought snakes home they wanted to see them and were more pleased if I gave them one to play with than if I brought them candy or some other plaything. Of course, I always took great care to show them the difference between poisonous and non-poisonous snakes. Some of the harmless snakes take, it seems, advantage of the feeling and horror they inspire and simulate the behavior of their formidable relatives by coiling, striking, and even producing a noise like that of rattlers by vibrating their tails rapidly in contact with dead vegetation. All, or nearly all, will use the teeth when cornered, but the bite is not followed by serious consequences.

If the wound made by the bite of a snake has the shape of a horseshoe, there is no danger that it was poisonous; but if the wound consists only of one or two separate punctures, the snake might have been a poisonous one, and, therefore, the wound should be attended to.[5]

The food of snakes consists of living animals, generally swallowed alive; only rarely do they eat a dead animal that they have not previously killed. Snakes that are kept in captivity seldom eat, but if they are provided with drinking water may hold out a whole year. Young snakes eat all kinds of living insects.

The farmers should not kill every snake they come across, as they generally do, because they are their best help in destroying field mice and wood mice, doing better work than a cat. I will here give only one instance. At a certain place where I formerly caught a great many snakes with only an occasional mouse nest under a rock, I now find, after the removal of most of the snakes, many mice nests, due undoubtedly to the absence of the snakes.

The teeth of the snakes are set backwards and merely serve as an organ of prehension, and the fangs, when present, as in our poisonous snakes, are used only in striking.

Some snakes are known to lay eggs which after a period produce young. Other snakes are known to retain the eggs within the body until the young have attained sufficient size and strength to care for themselves after birth. Still other species are supposed sometimes to lay eggs, at other times to bring forth living young, or to produce some eggs and some living young at the same time. There are, indeed, oviparous snakes and snakes which are ovoviviparous, and there is a conspicuous difference

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[5] In the most southern part of the state may occasionally be found a snake, *Elaps fulvius*, the Bead Snake, which will produce the same kind of a wound, but this snake is so easily recognized by its splendid coloring that the person bitten will know at once and take the necessary steps.

in their eggs. The eggs of the oviparous species are furnished with a thick, tough, flexible covering or "shell", while the eggs of the species which produce living young have coverings which are only thin and delicate. Now, should such eggs as the latter be laid any considerable period before the young are ready to be excluded, the thin envelopes would surely be torn during the writhings of the embryo. The eggs of the oviparous species are laid a considerable time before they are hatched. The tough coverings of such eggs protect them from attacks and injuries from without and at the same time resist the movements of the young snake within. So far as we know these eggs are deposited in the earth in piles of decaying vegetable matter and similar places. (Cope.)

A very curious structure deserves mention here. This is the "egg-tooth", a small tooth fixed to the united premaxillary bones and projecting forward slightly beyond the edge of the upper lip. It is present only in the embryo and is shed shortly after the escape of the young snake from the egg. The tooth is employed by the little snake in ripping open the tough egg covering in its efforts to escape from its prison. This tooth is found in all the young just emerging from the egg, of the oviparous species. (Cope.)

In Missouri all snakes hibernate. In summers with prolonged heat spells they become scarce, as the frogs and toads on which a good many snakes live have hidden. Sometimes we read in the papers of a "snake den" having been opened accidentally by "blasting", and a great number of different snakes all coiled together encountered. This is only natural as all or most of the snakes within a certain distance might have taken refuge in this small cave over winter. Very likely the entrance to the cave was just large enough for a snake to crawl into.

I shall now give a resumé of the classification of the snakes proposed by Dr. L. Stejneger in his valuable work, "Herpetology of Japan and Adjacent Territory," 1907.

"The following table of the superfamilies, families, and subfamilies of snakes gives the essential characters by which these divisions have been separated. There is still considerable divergence in the opinions of authors concerning the relative value of some of these divisions, but in breaking up the aglyph and opistoglyph 'series' I believe that a better recognition of the true relationships of their component parts can be obtained."

SYNOPSIS OF SUPERFAMILIES, FAMILIES, AND SUBFAMILIES.

Maxillary bone horizontal; no loral pit. *Natricoideae.*
None of the anterior maxillary teeth grooved or perforated. *Natricidae.*
Hypapophyses present throughout the vertebral column.
All maxillary teeth solid. *Natricinae.*
Hypapophyses absent in posterior dorsal vertebrae.
All maxillary teeth solid. *Coronellinae.*
Posterior maxillary teeth grooved. *Boiginae.*
Anterior maxillary teeth grooved or perforated. *Elapinae.*
Maxillary bone vertical. *Crotaloideae.*
A deep loral pit. *Crotalidae.*

"The above synopsis is chiefly based upon characters which either require more or less dissection or examination of the posterior maxillary teeth. The latter often presents difficulties, and in some cases must be resorted to in order to obtain absolutely reliable identification.

"The examination of the dentition must be made very carefully in order to avoid mistakes. The safest way is probably to dissect out one of the maxillary bones. This can be done very easily by running the point of a sharp knife between the supralabials and the underlying bone, cutting the tissue along the whole length of the latter. By forcing the point of the knife over the upper edge of the bone in the region of the eye the bone can be easily lifted up and the connecting ligaments severed. The adherent tissue may be carefully removed, though in most cases it is sufficient to let it dry. The teeth can now be examined conveniently. Care must be had not to mis-

take the space left by a lost tooth for a natural interval; if a tooth has fallen out, a distinct pit or depression is left on the alveolar edge of the maxilla. In counting the teeth the second inner row of loose teeth which are only the reserve teeth must not be taken into consideration. If the specimen is so hardened that it is difficult to open the mouth it should not be forced open by prying, a procedure apt to ruin the teeth and break the lower jaw, but the thick muscle at the corner of the mouth closing the jaws should be cut through on both sides. If properly done the specimen need show no outward sign of mutilation. The maxilla after being dissected out and cleaned should be placed in a small glass tube or vial and, provided with the same number as the snake, kept in the same bottle.

"The apial scale pits are usually distinctly visible under a fairly good magnifying glass. In some cases, however, they are rather difficult to discern. When the pits are not discovered at once the skin should be allowed to dry and then viewed at different angles to the light. The epidermis of scales of different parts of the body should be examined. In very doubtful cases it may even become necessary to remove some of the epidermis and examine it under a more powerful lens."

Dr. G. A. Boulenger has shown that the question whether the haemal processes are present on the posterior vertebrae, or not, can be easily ascertained by making an incision along the belly in the posterior fifth of the body, pushing aside the viscera and disarticulating the backbone by bending the body dorsally.

Artificial Key to the Genera of Non-Poisonous Snakes of the State of Missouri.

Anal plate divided.
  Dorsal scales more or less keeled.
    Rostral normal; not shovel-shaped or keeled.
      Three plates between the rostral and the eye.

Nasal single; anteorbital and loral present. *Opheodrys.*
Nasals 2; anteorbital present; loral absent. *Storeria.*
Nasals 2; anteorbital wanting; loral present. *Haldea.*
Four plates between rostral and eye (2 nasals, 1 anteorbital, 1 loral). Some of the outer rows of scales smooth; scale rows 25-29; ventral plates 200-270. Scale pores present. *Elaphe.*
All dorsal scales keeled; scale rows 19-33; ventrals 125-160. *Natrix.*
Rostral expanded and shovel-shaped, with a median keel. *Heterodon.*
Dorsal scales smooth.
Loral absent; anteorbital present. *Tantilla.*
Loral present; anteorbital absent.
Nasal single, pierced by nostril.
Dorsal rows of scales 13. *Carphophis.*
Dorsal rows of scales 19; prefrontals united. *Farancia.*
Nasals two, with nostril between them; dorsal scale rows 15-17. *Virginia.*
Both loral and anteorbital present.
Nasals two; anteorbital usually two.
Adult size large; pairs of subcaudal plates seldom fewer than half the number of ventral plates. Scale pores present. *Bascanion.*
Adult size small; pairs of subcaudal plates seldom more than one-third the number of ventral plates. *Diadophis.*
Nasal single; anteorbital single; subcaudals more than one-half the ventral plates. *Liopeltis.*
Anal entire.
Dorsal scales carinated; rostral normal.
Prefrontals two pairs; scales 25-35 rows. *Pituophis.*
Prefrontals one pair; scales 17-21 rows. Nasals divided. *Thamnophis.*
Prefrontals a single pair; scales in 19 rows; nasals single. *Tropidoclonium.*
Dorsal scales smooth.
Rostral normal. *Lampropeltis.*

Family Natricidae.

Subfamily Natricinae.

The Natricinae are without grooved teeth in the posterior part of the upper jaw. (Stejneger.)

Five genera are known in Missouri.

Genus NATRIX.

Form varying from stout to slender. Head distinct from the body. Crown-shields 9. Loral present. Anteorbitals 1 or 2. Postorbitals 2 or 3. Nasals divided with the nostril between. Scales conspicuously keeled; arranged in from 19 to 33 rows. Anal plate divided. (Hay.)

KEY TO THE SPECIES IN MISSOURI.

Scales in 29-31 rows. Numerous narrow cross bands, often broken up. *cyclopium.*

Scales in 27 rows. Scales keeled. Brown above with a series of rhomboidal dark spots on the back, which touch with their points. Beneath more or less blotched with black. *rhombifera.*

Scales in 23-25 rows. Belly with dark spots which are lateral and angular. *fasciata.*

Scales in 25 rows. Uniform reddish brown or blackish above reddish or yellow beneath. *fasciata erythrogaster.*

Scales in 23-25 rows. Color in form of brown blotches. Anteorbital one. Upper labials 8. Belly spotted. *sipedon.*

Scales in 25 rows. Belly unspotted. Dorsal and lateral rows of blotches alternate to the head. *transversa.*

Scales in 19 rows. All scales keeled. A dark vitta on the fourth and eighth dorsal rows. *grahamii.*

44. NATRIX CYCLOPIUM Duméril and Bibron. Cyclops Water Snake. Green Water Snake.

Tropidonotus cyclopium, Nerodia cyclopium.

Description.—Head swollen at the cheeks, narrowed forward. Rostral about twice as broad as high. Nasal large, nostril near the upper margin, but not quite dividing it into two plates. Loral large, widest below. One large anteorbital, widest above. Two postorbitals. Two internasals, triangular and about as long as wide. Prefrontals wider than long. Frontal twice as long as wide. Superciliaries much narrowed anteriorly. Parietals large. From two to three suborbitals. Upper labials, greatly developed, eight in number; the sixth and seventh much the largest. The sixth twice as long as high. Middle of the eye above the fourth upper labial. Post chin-shields shorter than anterior chin-shields. Six lower labials in contact with the anterior chin-shield. All dorsal scales keeled; those of the outer row slightly, those of the back very strongly, forming sharp longitudinal keels on the tail. Dorsal rows 27. Ventrals 144. Subcaudals 66 pairs. Anal divided.

Color.—Color brown above and yellow below. On the upper surface there are on each side two rows of alternating short cross bars of a darker color, which are about one scale wide, and are separated by in-

terspaces of about three scales. The median line for about a width of four scales is not spotted, or is very imperfectly so, forming a broad vertebral band of a color much darker than the general ground. The head is uniform brown; the lower part of the superior labial plates only being yellow. On the yellow ground of the inferior surfaces there appear, on the anterior third only, dark shades on the ventrals. These extend and blend so that on the posterior two-thirds of the body-length the color may be said to be bluish-brown, with yellowish subtriangular yellow spots pointing forward. (Cope.)

Size.—Length from point of head to vent 545 mm.; tail 180 mm. Total length 725 mm. Adult male.

Habitat.—Florida, Louisiana, Arkansas, Southern Illinois, and Missouri. Missouri localities: Poplar Bluff, Butler Co., and St. Francis River, Dunklin Co.

Habits.—My son shot a few specimens of this snake at Grinnell Lake, near Poplar Bluff, and I caught a few at the St. Francis River, near Bertig, Arkansas. They were sunning themselves on the moss, *Ceratophyllum emersum,* and other water plants. When disturbed they slid down into deep water—6 to 10 feet. July 3, 1904, I shot a female basking in the sun on water plants. I hit it in the eye, which only stunned it long enough for me to catch it. I kept it in captivity until September 20th, when it bore nineteen live snakes, 265 mm. long. I found this species quite common on the lower St. Francis River about August 20th.

Dates of capture.—May 19, 22; July 3; Aug. 20; Oct. 3.

45. Natrix rhombifera Hallowell. Diamond-backed Water Snake. Holbrook's Water Snake.

Tropidonotus rhombifer, Tropidonotus sipedon var. rhombifer, Tropidonotus fasciatus var. rhombifer, Nerodia holbrookii, Nerodia sipedon var. rhombifer, Nerodia rhombifer.

Description.—Head narrow. Rostral broader than deep, visible from above. Internasals much narrowed in front, as long as broad, or a little longer, as long as or shorter than the prefrontals. Frontal one and two-thirds to twice as long as broad, as long as its distance from the end of the snout, shorter than the parietals. Loral as long as deep or deeper. One anteorbital and three postorbitals, the lowest nearly meet-

ing the anteorbital under the eye. Upper labials 8, the sixth and seventh the largest; the eye over the fourth. Lower labials eleven; fifth and sixth the largest. Five lower labials in contact with the anterior chin-shield. Scales in 27 rows. All keeled. Ventrals 135-141. Subcaudals 62-70.

Color.—Ground color, above reddish gray. On the middle of the back there is a series of about 50 rhomboidal brown blotches. Alternating with the dorsal series there is, on each side, a series of similarly colored blotches. The lateral blotches reach down to the ventrals and lower. The rhomboidal blotches of the back touch with their corners. Thirty-two of these lie in front of the vent. Occasionally there is a little confusion in the relations of the blotches of the different series, but not much. The belly is yellowish white, with some triangular spots of black, giving it a speckled appearance. The head is smoky brown above as far down as the upper edges of the upper labials. The lower edges of these are yellow, with a black border on the hinder edge. The lower labials are similarly yellow, with black posterior edges.

Habitat.—Michigan to Louisiana and Texas, Arkansas, Missouri and Kansas. Missouri localities: St. Louis, Stoddard, Butler, Dunklin, Jasper, Johnson and St. Charles Counties. In Illinois, St. Clair, Madison and Monroe Counties.

Habits.—This species is one of the common water snakes in this neighborhood, but more so across the river in the so-called American Bottom in Illinois. Middle of April I found this rather vicious looking snake already mated, lying on the branches of small trees and shrubs, overhanging the borders of creeks, ponds and sloughs, from which at the slightest noise they quickly dropped into the water. When cornered they bite viciously. In hot weather they are often found under logs and boards, partly in the water. To one which I had in captivity for quite a while but did not feed regularly I brought a supply of six large toads, which disappeared within a quarter of an hour notwithstanding the struggles made by the victims. Every time the snake swallowed one the neck was so distended that the scales appeared only at considerable intervals. These snakes bear live young.

Dates of capture.—April 9, 16, 29; July 3; Sept. 5.

46. Natrix fasciata Linnaeus. Banded Water Snake. Mocassin. Southern Water Snake.

Natrix fasciata fasciata, Natrix sipedon fasciatus, Natrix sipedon, Tropidonotus fasciatus, Nerodia fasciata, Nerodia sipedon fasciata, Coluber fasciatus, Coluber porcatus.

Description.—Head elliptical, tapering to the snout. Dorsal rows of scales twenty-three to twenty-five, all carinated; carinae on the dorsal region very conspicuous. Scales on the outer row feebly keeled, broad and rounded posteriorly. Tail one-fourth of total length, very much tapering. Rostral broader than deep, visible from above. Frontal plate elongated, as long as its distance from the end of the snout. Superciliaries very narrow, one preorbital and three postorbitals. Upper labials eight; fourth and fifth entering the eye, sixth and seventh the largest. Temporals 1 plus 2 or 1 plus 3. The large temporal shield in contact with the postorbital, and followed by two rather large scuta. Lower labials 10, the fifth and sixth the largest; five lower labials in contact with the anterior chin-shields. Ventrals 128-154. Anal divided. Subcaudals in 58-82 pairs.

Color.—Ground color above in the adult uniform blackish brown, lighter in young, crossed by transverse yellowish white bars, which widen out at the sides. About 35 sub-triangular or oblong red spots on the flanks. These spots or blotches reach half way across the ventrals and alternate. Middle of the top of the head dark brown. A light band from the rostral through the eye to the neck, where it joins the yellow white color of the throat and chin. Upper and lower labials also yellowish white with the posterior upper corners dark brown, more faintly on the lower labials.

Habitat.—This form is characteristic of the Austro-riparian region, ranging up the Mississippi and Ohio to southwest Indiana, southern Illinois and Missouri, and southwestward throughout Arkansas and Texas. Missouri localities: Butler, Stoddard, and Dunklin Counties.

Habits.—Down in the Sunken Lands of Missouri and in the adjoining counties this species is of common occurrence basking in the sun on water plants. They feed on small fish and crawfish. A female which I had in captivity gave birth to twenty-three young ones on the 26th of August.

Dates of capture.—April 24, 26; July 3; Sept. 5.

47. NATRIX FASCIATA ERYTHROGASTER Shaw. Red-bellied Water Snake.

Tropidonotus fasciatus erythrogaster, Tropidonotus sipedon erythrogaster, Natrix sipedon erythrogaster, Tropidonotus erythrogaster, Natrix sipedon fasciata, Nerodia erythrogaster, Nerodia sipedon erythrogaster, Coluber erythrogaster, Anguis ventre cuprei coloris.

Description.—Scutuation of the head the same as the preceding species. Dorsal rows of scales twenty-three, all strongly keeled on the posterior third of the body, forming very conspicuous and continuous ridges nearly to the end of the tail. Tail one-fourth of total length. Ventrals 150. Subcaudals 68 pairs.

Color.—Adult specimens are of a dark reddish brown (in alcohol bluish black) color above, lighter on the sides; a lateral not well defined band of dull blue extends along the abdominal scutellae. Body beneath uniform dull yellow, tail bluish. All the specimens that came under my observation had in life a plain yellowish abdomen, with the exception of one from Quincy, Ill., which had a red abdomen, which turned yellow in alcohol.

Young, born in captivity, showed at the age of two days the following color pattern. The first impression is that it is a young *Natrix fasciatus*. Twenty-seven saddle-like blotches of dark brown, nearly black, on the back. These blotches extend over the back from the ventral on one side to the other. These blotches are widest on the back, where they are only separated from each other by a light narrow streak. They become greatly reduced in width at the sides, where the space between the blotches is red. On the posterior third of the body the blotches are of the same dark color as those on the back and in a red field. On the anterior two-thirds of the body the ventrals have a dusky bluish edging on the sides, leaving the central part plain yellow. The rest of the body and the tail, all the ventrals and subcaudals, have an edging of the same bluish color across the posterior edge of the plates.

Size.—From tip of snout to vent 875 mm.; from vent to end of tail 235 mm. Total length 1,110 mm.

Habitat.—Louisiana, Arkansas, Oklahoma, Kansas, Missouri, Illinois, Indiana, and Michigan. Missouri localities: Dunklin and Butler Counties. In Illinois, St. Clair and Randolph Counties.

Habits.—This snake, when lifted up by the tail shows a triangular head, with a greatly reduced neck, and resembles very much a poisonous snake—such as the Cotton Mouth. It feeds on fish and tadpoles, often swallowing fish over six inches long. On May 13th I caught one with

the tail of a mud-eel (*Siren lacertina*) sticking out of its mouth. When disgorged, the head of the eel had been nearly digested. A female which I found in Randolph County, Ill., gave birth to thirteen young ones on September 4th. From one of these the above color description was made.

48. Natrix sipedon Linnaeus. Common Water Snake. Water Moccasin.

Natrix fasciata sipedon, Tropidonotus sipedon, Tropidonotus fasciatus sipedon, Tropidonotus sipedon sipedon, Nerodia sipedon, Nerodia sipedon sipedon, La Couleuvre sipède, Coluber sipedon.

Description.—Rostral wider than high, only a small portion visible from above. Internasals wedge-shaped, longer than wide. A single nasal with a groove below the nostril. Sometimes apparently two plates with the nostril between them. Loral quadrangular, higher than long. Prefrontals wider than long. One large anteorbital, its superior angle reaching nearly to the frontal. Frontal narrow, sides concave, much longer than wide—one and one-half times longer than wide. Parietals short and broad. Superciliaries narrow in front. Postorbitals three. Upper labials eight or nine; often eight on one side and nine on the other. Eye above the fourth and fifth labial; sixth and seventh the largest. Temporals 1-3. Lower labials 10; fifth and sixth the largest. Fifth labial in contact with anterior chin-shield. Head distinctly marked off with a more slender neck. Body moderately slender. Tail cylindrical, tapering and of moderate length. Twenty-three rows of dorsal scales, all keeled, with the exception of the outer row, which is only slightly keeled, being nearly smooth. Ventrals 138. Anal divided. Subcaudals 60 pairs.

Color.—A dorsal series of large brown spots, three to five scales long, separated by light interspaces of one-half to two scales long. Alternating with the dorsal spots are lateral spots of the same color. These spots are one and one-half to two and one-half scales long, reaching into the ventrals. These side spots are separated by lighter interspaces from two to three scales long. Anteriorly the latter spots are often indistinct, becoming frequently confluent with the dorsal spots, forming cross bands. Belly maculated by many brown spots bordered with black. Spots more numerous posteriorly. In old specimens the general color markings are obscured and the snake appears plain brown. Top of head brown. Upper part of upper labials brownish, like the head, lower part yellowish. Lower labials, chin and throat yellowish. Posterior edge of upper and lower labials with a dark streak.

Habitat.—Eastern United States west to western Mis-

souri. Missouri localities: St. Louis, Jefferson, St. François, Cape Girardeau, Shannon, Dunklin, Ozark, Stone, Jasper, Jackson, Johnson, Marion, Crawford, Lewis, Pike, Montgomery, St. Charles, Warren, and Randolph Counties. Illinois localities: Madison, St. Clair, Monroe, Randolph, and Union Counties.

Habits.—This snake is one of the commonest water snakes in the states. It feeds largely on small fish, tadpoles and frogs. The species is ovoviviparous. One in captivity laid 19 eggs on June 20th. Another one bore on Sept. 15th 18 young ones of an average length of 235 mm.

49. NATRIX SIPEDON TRANSVERSA Hallowell. Woodhouse's Water Snake.

Tropidonotus sipedon transversus, Natrix fasciata transversa, Tropidonotus transversus, Tropidonotus sipedon woodhousei, Tropidonotus woodhousei, Nerodia transversa, Nerodia woodhousei.

Description.—Dorsal rows of scales twenty-five, all carinated. Three series of subquadrate black blotches, a dorsal and two lateral, the latter vertically elongated. A double yellow occipital spot. A yellow spot between the superciliaries and frontal plates. A black line from posterior rim of the eyes to angle of mouth. The head is broad behind and tapers forward, very much flattened above. The labials are eight above and eleven below; the fifth, sixth, and seventh the largest on both jaws. Ventrals 139-143. Anal divided. Subcaudals 65-78 pairs. (Cope.)

Color.—Ground color dusky, with a dorsal series of subquadrangular brown blotches, alternating with the lateral series as far as the head, with anterior and posterior margins nearly parallel, rarely tapering downward, and reaching the ventrals. The fuscous space between the lateral blotches is wider than that occupied by the blotches themselves. Along the tail both the dorsal and lateral blotches are small and subcircular. Underneath the color is yellowish, and the scutulae in the young margined posteriorly with black, while in the adult the middle region of the ventrals is unicolor. The head is brownish-black, with a double yellow spot near the commissure of the parietal plates, and two spots of the same color on the commissural line between the frontal and superciliaries. A black streak extends from the posterior rim of the eye to the angles of the mouth. (Cope.)

This form has normally two more rows of dorsal scales than either *N. fasciata* or *N. sipedon*. The alternation of the dorsal and lateral

spots is more universal than in either of them, while the unspotted abdomen relates it to *N. f. erythrogaster* of the same region. (Cope.)

Habitat.—This species is restricted to Texas, Arkansas, Oklahoma, and Missouri. Missouri localities:—P. R. Hoy in his Journal of an Exploration of Western Missouri in 1854 mentions the capture of *Nerodia transversa* near Lexington, Lafayette Co., Mo., on May 12th. Last year Mr. B. F. Bush of Courtney, Jackson Co., Mo., sent me a specimen caught in that neighborhood.

Habits.—Having never caught one of these snakes, I can say nothing as to its habits, but, which, undoubtedly, are very similar to those of other water snakes.

50. NATRIX GRAHAMII Baird and Girard. Graham's Water-Snake.

Tropidonotus grahamii, Regina grahamii, Regina leberis var. grahami.

Description.—Rostral broader than deep, visible from above. A single nasal on each side obliquely grooved below the nostril. Two anteorbitals, two postorbitals. Internasals longer than broad, as long as the prefrontals or a little shorter. Frontal one and two-thirds as long as broad, as long as its distance from the end of the snout, shorter than the parietals; loral as long as deep. Parietals large. Temporals 1-2. Seven upper labials, third entering the eye; fourth and fifth the largest. Lower labials ten; fourth and fifth the largest. Four lower labials in contact with the anterior chin shields, which are much shorter than the posterior. Head small, not distinct from the neck. Dorsal scale rows nineteen, all keeled with the exception of the outermost, which is very feebly keeled. The three outer rows sensibly the largest, with the scales truncated posteriorly. Ventrals 156-173. Anal divided. Subcaudals 54-65 pairs. Tail about two-tenths the length of the body.

Color.—Olive brown above, uniform or with a lighter black edged dorsal stripe. A broad yellowish or pale olive, black edged, stripe along the three outer rows of scales. Upper lip and lower parts yellowish, with or without a median black line or a series of spots on the posterior part of the belly and under the tail.

Habitat.—This species occurs from Michigan to Louisiana and Texas. Missouri localities:—St. Louis, Jefferson, Jasper, Johnson, and St. Charles Counties. Illinois localities:—Madison and St. Clair Counties.

Habits.—This species is quite numerous in the neighborhood of St. Louis on both sides of the river. It is an agile and timid species, frequenting the borders of streams and lakes, hiding under decaying logs and boards near the edge of the water.

Dates of capture.—April 15, 22; May 24; November 13.

Genus THAMNOPHIS.

Cephalic plates normal, loral present, nasal divided, with the nostril between. Anteorbital one, postorbitals three. Head separated from the body by an evident neck. Body moderately slender. Dorsal scales keeled, arranged in 19 to 21 rows. Anal entire.

This genus is closely allied to the genus *Natrix*, but differing in the undivided anal plate. It is confined to North America. The general color consists of three light stripes on a darker ground, with alternating or tessellated spots.

Key to the Missouri Thamnophis.

Lateral stripe on the third and fourth rows of dorsal scales.
- Dorsal scales in 19 rows. *proxima faireyi.*
- Dorsal scales in 21 rows. *radix.*

Lateral stripe on the second and third rows of dorsal scales.
- Dorsal scales in 19 rows. *sirtalis.*

51. Thamnophis proxima faireyi Baird and Girard. Fairey's Ribbon Snake.

Thamnophis saurita faireyi, Eutaenia proxima faireyi, Eutainia saurita faireyi, Eutaenia faireyi, Eutaenia proxima, Eutaenia saurita, Eutainia faireyi, Tropidonotus saurita var. faireyi.

Description.—Rostral broader than deep, visible from above, internasals as long as broad, a little shorter than the prefrontals. Frontal one and a half to one and two-thirds times as long as broad, as long as its distance from the end of the snout. Loral as long as deep; one pre- and three post-orbitals. Temporals 1-2 or 1-3. Eight upper labials; fourth and fifth entering the eye, sixth and seventh the largest. Lower labials ten; fifth and sixth the largest. Five lower labials in contact with the anterior chin shields, which are shorter than the posterior. Body slender. Head distinctly marked off by the more slender neck. Tail long, tapering less than one-third of the total length. Dorsal scale rows 19, all strongly keeled. Ventrals 160-175. Anal entire. Subcaudals 105-115.

Color.—Color above blackish-brown; beneath greenish-white. Lateral

stripe on third and fourth rows of scales. Dorsal and lateral stripes uniform in color. Color above and below lateral stripes the same.

Habitat.—Fairey's Ribbon Snake is found throughout the Mississippi Valley from northern Indiana and Wisconsin to the mouth of the Mississippi. Missouri localities:—St. Louis, Butler, Pemiscot, Howell, Stone, Phelps, Jackson, Franklin, St. Charles, and Montgomery Counties. Illinois localities:—Madison, St. Clair, Monroe, and Randolph Counties.

Habits.—This species is found along the border of creeks, ponds and sloughs. It is a very active snake and feeds on tadpoles, small frogs and salamanders. The Ribbon Snake swims and dives with the great ease and agility of the Water Snakes, and takes refuge when pursued among the stones and other accumulations along the water edge, or will hide beneath some aquatic plants beneath the surface of the water.

Ditmars in his Reptile Book gives such a fine account of how this snake procures its food that I shall give it in full:—"The high, rasping croak of a wood frog denotes something to be the matter. Peeping through the undergrowth a wood frog was seen struggling in the jaws of a Ribbon Snake. So vigorous was the batrachian that it tore itself from the reptile's grasp and started away in a series of frantic hops, with the snake in pursuit. So lightning-like were the undulations and progress of the pursuer that it readily kept up with the frog, although the former had a start of several feet, gained immediately after its escape from the snake's jaws. After a dozen frenzied leaps, the frog paused to recover breath, and the snake, momentarily losing sight of it, stopped as well, but was all attention with head and neck upraised, eyes staring in the direction of the prey, and flashing tongue. Imagining the danger past the frog settled down to rest. But woe to the unfortunate creature, a single move brought instantaneous fate. With the characteristic movement of frogs and toads it folded its limbs tighter to its

body and flattened to the damp ground—if that slight movement betrayed its presence to the snake, which responded with a dash so quick and unerring that before the frog could make a jump it was in the reptile's jaws. The observer remained quiet until the frog was swallowed and the snake, with the outline of the meal clearly defined, glided away among the bushes."

Dates of capture.—April 8, 14, 16, 22; May 6, 13, 16, 20, 21; Sept. 2, 30; Oct. 18, 23.

52. THAMNOPHIS RADIX Baird and Girard. Racine Garter Snake. Prairie Garter Snake.

Eutainia radix, Eutaenia radix, Eutaenia haydenii, Eutaenia radix twiningii, Eutaenia radix melanotaenia, Eutaenia sirtalis var. radix, Tropidonotus sirtalis var. radix and haydenii, Tropidonotus ordinatus var. radix.

Description.—Rostral wider than high, visible from above. Nasals two, nostril almost entirely in the anterior. Frontal hexagonal; loral quadrangular. One large anteorbital touching or nearly touching the frontal. Postorbitals three. Parietals truncate behind. Temporals 1—2. Seven upper labials, sometimes seven on one side, eight on the other; third and fourth entering the eye; fifth and sixth the largest. Lower labials ten (occasionally nine or eleven), fifth and sixth the largest. Head rather small, wider than the neck. Dorsal scales either in 19 or 21 rows, prominently keeled; the fifth row as broad as long, truncate behind, and not keeled. The appearance of this snake is distinctly rough. Ventral plates 140-170. Anal entire. Subcaudals 51-80 pairs. Tail one-quarter to one-fifth of total length.

Color.—Above light, mostly dark, olive brown, with three stripes of yellow and series of black spots. The dorsal stripe occupies the median row of scales and the adjacent half of the next row on each side. The lateral stripe lies on the third and fourth rows of scales on the anterior part of the body, and descends to the third row posteriorly. One or two series of black spots are usually to be seen below the lateral stripe, on the first and second rows. Between the lateral stripe and the dorsal one are two series of quadrate black spots. Sometimes they are obscure. The upper surface of the head is dark olive, with two little yellow dots on the middle suture of the parietals. The upper labials are yellow, with a black edging posteriorly. Lower jaw and throat yellow. Abdomen greenish or olive. On the outer ends of the ventrals there is, on each side, a row of black spots, and the posterior edge is often wholly edged with the same color. (Hay.)

Habitat.—Its distribution is more northern, being reported east of the Rocky Mountains from Canada south to Montana, Minnesota, Wisconsin, Illinois, Indiana, Dakota, Wyoming, Colorado, Kansas, Nebraska, Missouri, Arkansas, and Texas. Missouri localities:—St. Charles and Montgomery Counties. In Illinois, Madison County. In his "Variations and Genetic Relationship of the Garter Snakes" Mr. Ruthven gives "Madison County, Missouri," evidently a mistake.

Habits.—So far I have only found this species on the so-called "wet prairie" near Edwardsville, Madison Co., Ill., on the "Dardenne Prairie," St. Charles Co., Mo., and on the prairies of Montgomery Co., near Montgomery City, Mo. These prairies are inundated annually by high waters of the Mississippi and Missouri Rivers. Many of these prairies have never been cultivated and are overgrown with high rank grass. Wherever there is any water left after these overflows, the snakes are found in abundance. When intruded upon they try to escape. They feed on small fish, frogs, and tadpoles. I once caught one that was gorged with ten small gars about four or five inches long. To eleven of these snakes, which I had in a vivarium, I brought home seven frogs, *Rana pipiens.* Such a fight ensued that one victim would be tackled by two or three snakes, each trying to swallow the frog. Of course finally the strongest one secured the coveted morsel, but only after the unfortunate ones had held on to the very edge of the mouth or even to the teeth of the winner.

Dates of capture.—April 15, 22, 29; July 4.

53. Thamnophis sirtalis *Linnaeus.* Common Garter Snake. Striped Snake.

Eutainia sirtalis, Eutaenia sirtalis, Eutaenia sirtalis sirtalis, Tropidonotus sirtalis, Coluber ordinatus var. sirtalis, Eutainia sirtalis sirtalis, Tropidonotus bipunctatus, Tropidonotus taenia, Coluber sirtalis, Le sirtale, Anguis viridis maculatus.

Description.—Rostral wider than high, visible from above. Nasals two, nostril between. Frontal hexagonal. One anteorbital, three post-

orbitals. Upper labials seven, third and fourth entering the eye; fifth and sixth the largest. Ten lower labials, fifth and sixth the largest. Anterior chin shields shorter than posterior. Five lower labials in contact with the anterior chin shields. Temporals 1-2. Head distinctly wider than neck. Body moderately slender, tail from one-fourth to one-fifth of total length. Dorsal rows of scales 19, all keeled. Ventrals 140-170. Anal entire. Subcaudals 50-90 pairs.

Color.—Color from light olive-brown to blackish brown above, with three longitudinal green or yellow stripes. The dorsal stripe occupies one and two half rows of scales. The lateral stripes occupy the second and third rows of each side. The ground color may be nearly uniform, or with two series of black spots on each side. Black spots are generally present on the side, beneath the lateral stripes. Bluish green beneath, with a series of black spots on the scutis at each side. Head brown above, a pair of small yellow spots at the inner edges of the parietals. Upper labials greenish, uniform, or with black posterior margins. When stretching the skin on the sides numerous white lines and spots are visible between the scales. (Garman.)

Habitat.—From Canada south to Florida, west to Texas, Oklahoma, Kansas, and Nebraska. Missouri localities:—St. Louis, Jefferson, Shannon, Oregon, Ozark, Stone, Jasper, Jackson, Johnson, Phelps, Crawford, St. Charles, Warren, Montgomery, Randolph, Lewis, and Pike Counties. In Illinois, Madison, St. Clair, and Monroe Counties.

Habits.—This species is the most common snake in the state. I have observed it as early as March 5th and as late as November 23rd. The Garter Snake is found mostly in moist places near to or swimming in the water; often it is found near fences and in pastures. Garter Snakes feed on frogs, toads, small fish, worms, and insects. Several times I have observed a cat playing with one, finally eating it. March 13th, while pulling out a rotten stump about 30 inches in the earth, I found a ball of snakes in a torpid condition. It consisted of one large adult Garter Snake, nine young ones of the same species, and one half grown Water Snake, *Natrix sipedon.* When handled Garter Snakes give off an offensive odor like

most water snakes. Like all ovoviviparous snakes, they bring forth large broods of young snakes.

Dates of capture.—March 5, 13; May 26; June 3; Oct. 16; Nov. 23.

Genus STORERIA.

Hypapophyses developed throughout the vertebral column. Maxillary teeth 14 to 18, equal; mandibular teeth equal and not grooved. Head distinct from the neck. Eye rather small. Cephalic plates normal, loral plates absent. Anterior and posterior orbital plates present. Body subcylindrical. Tail comparatively short. Dorsal scales keeled. Anal plate divided. Subcaudal plates in pairs.

KEY TO THE MISSOURI SPECIES.

Dorsal scales in 17 rows.	*DeKayi.*
Dorsal scales in 15 rows.	*occipitomaculata.*

54. STORERIA DEKAYI Holbrook. DeKay's Snake. DeKay's Brown Snake.

Ischnognathus deKayi, Tropidonotus deKayi, Coluber ordinatus.

Description.—Rostral as high as wide or a little wider. Snout projecting beyond the lower jaw. Nasal divided, nostril partly in the prenasal. Internasals broader than long, much shorter than the prefrontals. Frontal about one and a half times as long as broad, longer than its distance from the end of the snout, shorter than the parietals. One anteorbital. No loral. Two, sometimes three, postorbitals. Upper labials seven, third and fourth entering the eye. Temporals 1-1 or 1-2. Lower labials seven, fourth and fifth the largest. Four labials in contact with the anterior chin shield. The anterior chin shield longer than the posterior. Head larger than the neck, flat above and rather high. Dorsal scales in 17 rows, all keeled, the first row weakly. Ventrals 120-145. Anal divided. Subcaudals 40-60. Tail one-fifth of the total length.

Color.—The color of the upper surface is yellowish or reddish-ash, brownish-olive, or even chestnut. The middle of the back with a paler, clay-colored, dusky-edged band, extending from the occiput to the end of the tail, and about three or four scales wide. On each side of this dorsal band is a row of brown or black spots, about the length of two scales apart. Sometimes the color above is uniform. Below the dots mentioned, other dots are occasionally seen. The color of the lower surface is whitish or yellowish in alcoholic specimens, but in life is often salmon or red. The ventrals sometimes have one or two dots of brown at the outer ends. Plates of the head brownish, with some minute dots. There is a large brown blotch just behind the head on

each side, separated by the dorsal band; another spot on the side of the head and across the corners of the mouth, and a small black blotch under the eye. (Hay.)

Habitat.—This snake has a distribution from Maine to the Mississippi Valley, and south to the Gulf of Mexico. Specimens from Kansas and Texas have also been recorded. Missouri localities:—St. Louis, Jefferson, St. François, Stoddard, Oregon, Stone, Jackson, Miller, Crawford, and Warren Counties. Illinois localities:—St. Clair and Randolph Counties.

Habits.—I should call this species aquatic. I secured my first specimen accidentally in a dip net while fishing for Newts, and since have found many near or in water. Those captured on dry land were never far from water. This snake is very common in this neighborhood, being generally taken for a young water snake. Its food consists of various insects—crickets, grasshoppers, etc. It is said to be ovoviviparous.

Dates of capture.—Mar. 20; May 3, 24; Sept. 1; Oct. 15, 26; Nov. 1, 13.

55. STORERIA OCCIPITOMACULATA Storer. Storer's Snake. Red-bellied Snake.

Ischnognathus deKayi var. B., Ischnognathus occipito-maculatus, Coluber venustus, Coluber occipito-maculatus.

Description.—Rostral broader than deep, visible from above. Nasal divided; nostril almost entirely in the prenasal plate; postnasal in contact with the pre-oculars. Internasals broader than long, shorter than the prefrontals. Frontal hexagonal, about one and a half times as long as broad, longer than its distance from the end of the snout, and shorter than the parietals. Superciliaries narrower in front than behind. Two pre- and two post-orbitals. Temporals 1-1 or 1-2. The first temporal extends for half the length of the sixth labial. Upper labials six; third and fourth entering the eye, fifth and sixth the largest. Lower labials seven, fourth and fifth equal in length, but the fifth wider. Four lower labials in contact with the anterior chin shield. Posterior chin shield shorter than the anterior. Scales in 15 rows, all keeled. Ventrals 115-140. Anal divided. Subcaudals 38-60 pairs. Muzzle rather short. Eyes larger than in DeKay's Snake.

Color.—The color above is olive or chestnut brown, uniform or with

a lighter dorsal stripe, three scales in width. A stripe of the same color on the outer row of scales. On each side of the dorsal stripe two rows of minute brown spots are sometimes present. The spots are on the bases of the scales of the third row from the dorsal. Belly whitish-yellow to greenish in alcoholic specimens but blood red in life. The ends of the ventrals are often very finely spotted with brown, Just behind the occipitals is a salmon-colored blotch, and behind the angle of the mouth is another blotch of the same color. The top of the head is brown.

Size.—From snout to vent 250 mm.; from vent to end of tail 62 mm. Total length 312 mm.

Habitat.—Eastern United States, east of the Rocky Mountains, south to Texas. Missouri localities:—St. Louis, Jefferson, Oregon, Ozark, Stone, Crawford, and Montgomery Counties.

Habits.—This snake is not as abundant as the preceding one—I should say rather scarce. I found a fine Red-Bellied Snake under leaves that had been blown against an old log; others I have found under rocks. It is said that this snake is somewhat nocturnal. Dr. O. P. Hay found a slug in the stomach of one of these snakes.

Dates of capture.—April 15; May 2, 3; June 3, 4.

Genus TROPIDOCLONIUM.

Head not distinct from body. Teeth equal. Hypapophyses present on the posterior part of the vertebral column. Cephalic plates normal; two internasals, rostral not prominent. One nasal and one loral. Hemipenis with two apical papillae. Dorsal scales in nineteen rows, all keeled, except the first and second rows. Subcaudals in two series.

56. TROPIDOCLONIUM LINEATUM Hallowell. Lined Snake.

Tropidoclonium lineatus Iowae, Ischnognathus lineatus, Storeria lineata, Microps lineatus.

Description.—Rostral low. Two internasals, right angular in shape. Frontal small, shorter than the length from the end of snout, sides parallel, anterior border large. Loral longer than high. Prefrontals almost square. One nasal, nostril in the anterior part. One pre- and two post-orbitals. Temporals 1-2 or 1-3. The lower temporal in the second row extending down between the fifth and sixth upper labials. Upper labials six, fifth and sixth the largest, third and fourth entering

the eye. Lower labials six, fourth and fifth the largest. Anterior chin shields longer than the posterior. Four lower labials in contact with the anterior chin shields. Head not distinct from the body. Body rather stout, thicker in the middle, tapering abruptly. Dorsal scales in 19 rows, all keeled, except the first and second rows, which are smooth. Ventrals 140-153. Anal entire. Subcaudals 26-43 pairs. Tail short.

Color.—A yellow dorsal stripe, covering one and two half rows of scales, extends from the nape to the tip of the tail. A lateral stripe is present on the second and lower half of the third row of scales. This stripe is yellowish and mottled with brown. A row of black dots on each side of the dorsal stripe and another row near the lateral stripe. Color above light brown to dark brown. Inferior row of scales brownish. Belly greenish, with two rows of triangular black spots down the middle. Upper part of head mottled with black and brown. Superior labials and lower part of temporals drab. Under part of head whitish, often maculated with small black spots.

Size.—From end of snout to vent 348 mm.; from vent to point of tail 37 mm. Total length 385 mm.

Habitat.—Texas, Oklahoma, Kansas, Iowa, and Missouri.

Habits.—On October 11, 1890, I wrote to Dr. L. Stejneger of the National Museum, upon request, what I knew of this species. After a lapse of twenty years I have nothing to add to what I wrote at that time, which was as follows:—"This snake is only found to my knowledge along the river front of the city of St. Louis, near the Arsenal ground. The place in which it is found covers a space of about three blocks, and consists of an abandoned and partly refilled quarry. Here they live among and under the rocks, in the ground under bushes, feeding on worms and insects—a fact which I ascertained by examining the contents of their stomachs. They were once quite common—some thirty years ago—but are now getting scarce, owing to the location being utilized for railroad purposes. Having kept specimens in captivity, I am able to state that this species is ovoviviparous, one of them having brought forth as many as six young snakes, which were 90 mm. long."

A large flood of the Mississippi at one time drove them

from their subterranean haunts, and a good many were found in the northern part of the city at the settling reservoirs of the city water works at Bissell Point. Most of them were dead, however, when discovered. Dr. P. R. Baer gave me two specimens, which his son had caught in their yard on top of a hill near O'Fallon Park. I also found one in a quarry south of the River Des Peres in St. Louis County. The species seems to be nocturnal and of burrowing habit.

Genus HALDEA.

Head elongated, distinct from the body. One internasal. Prefrontals large, entering together with the loral into the orbit, thus suppressing the anteorbitals. Postorbital one. Two nasals. Dorsal scales in seventeen rows, all keeled. Anal divided. Subcaudals also divided. Vertebral column with hypapophyses throughout.

57. HALDEA STRIATULA Linnaeus. Little Brown Snake.

Natrix striatulus, Calamaria striatula, Virginia striatula, Potamophis striatula, Conocephalus striatulus, Coluber striatulus, Serpent strié.

Description.—Rostral small, nearly as deep as broad. But one internasal, which is twice as broad as long. Prefrontals reaching to the orbit. Frontal about one and a half times to twice as long as broad, as long as or a little longer than its distance from the end of the snout. Two nasals, nostril in the posterior margin of the anterior nasal plate. Loral at least three times as long as deep, reaching to the orbit. One postorbital. Temporals 1-1. Five upper labials, third and fourth entering the eye; fifth the largest. Six lower labials; four in contact with the anterior chin shields, which are much longer than the posterior.

Head small, scarcely wider than the neck. Body cylindrical. Dorsal scales in seventeen rows, keeled; the outer row on each side conspicuously broader and smooth, or very feebly keeled. Tail short, tapering much. Ventrals 119-130. Anal divided. Subcaudals 25-45 pairs.

Color.—Color above grayish or reddish brown, beneath salmon color in life, yellowish in alcoholic specimens. A light chestnut band across the parietals, spreading over the angle of the mouth. This band is often wanting.

Size.—Total length 250 mm. Tail 42 mm.

Habitat.—Virginia, south to Florida, west to Alabama, Louisiana, Texas and up the Mississippi Valley to Ar-

kansas and Missouri. Missouri localities:—Jefferson and Jasper Counties.

Habits.—Found in damp places under rotten logs and rocks. Their food consists of worms, grubs and small beetles. This species seems to be of a secretive or burrowing habit.

Dates of capture.—March 22; May 13, 30.

Subfamily Coronellinae.

The coronelline snakes embrace a great variety of forms of arboreal or terrestrial habits, and consequently of the most different physiognomy. Having no grooved fangs of any description, they are of course nonpoisonous. (Stejneger.)

Genus bascanion.

Head distinct; cephalic plates normal. Maxillary teeth increasing gradually in size posteriorly, not grooved. Scales smooth, in an odd number of series. Scale pores present. Subcaudals in two series. Anal plate divided. Two preoculars. Loral present. Two nasal plates. Tail more than one-fourth of the total length. Pairs of subcaudals seldom fewer than one-half the number of ventrals.

Key to Missouri Species.

Seventeen rows of scales. Seven upper labials. Bluish-black or greenish above. *constrictor.*

Seventeen rows of scales. Seven or eight upper labials. Olive to brownish above, yellow underneath. *constrictor flaviventris.*

Seventeen rows of scales. Eight upper labials. Head brownish, color becoming lighter towards the tail. Young, brown, cross banded, the bands often persisting in the adult. *flagellum.*

58. Bascanion constrictor Linnaeus. Blue Racer. Black Snake.

Zamenis constrictor, Coluber constrictor, Bascanion foxii, Bascanium constrictor, Bascanion fremontii, Coluber mormon, Coryphodon constrictor, Hierophis constrictor.

Description.—Rostral triangular, as wide as high, the portion visible from above measuring one-third to one-half its distance from the frontal. Internasals shorter than prefrontals, almost elliptical, short and broad. Prefrontals large, slightly wider than long. Frontal broad in front, much narrower posteriorly, lateral margins concave, a little shorter than the parietals. Supraorbitals broad behind, slightly narrowed in front. Parietals short, truncate. Nasals two, about equal in size. Loral higher than long. Preorbitals two; the lower very

small. Postorbitals two, often three. Temporals 2-2 or 3-3. Upper labials seven; third and fourth entering the eye, sixth and seventh the largest. Lower labials eight, occasionally nine. Four lower labials, in contact with the anterior chin shield, which is a little shorter than the posterior; fifth the largest.

Head distinct from the body. Eyes large. Snout moderately prominent. Body long and slender. Dorsal rows seventeen, all smooth, the outer rows as wide as long. Ventrals distinctly angular laterally. 170-185. Anal divided. Subcaudals 56-100 pairs.

Color.—Color above uniform deep blue-black or olive-brown, slate-gray or greenish white beneath. Lower jaws and chin, and sometimes the edge of the upper labials, are often white.

The colors of the young Black-snake are so different from those of the adult that one would hardly suspect it to be the same species. Instead of being of a uniform color above, they are much blotched and spotted. There is a series of reddish-brown blotches with black borders along the middle of the back, but disappearing on the tail. These blotches are separated by a whitish gray bar, and are about three scales long, and reach down to the fourth row of scales on each side. The sides are furnished with many specks and spots of brown. The intervals between the spots are grayish or olive. The head is mottled and speckled. Below the color is greenish-white, with three or four specks of brown on each scale. Specimens over 450 mm. begin to assume the colors of the adult. (Hay.)

Size.—Total length 1150 mm. Tail 290 mm. The largest one I ever captured measured 2198 mm.

Habitat.—Eastern United States, west to Kansas and Texas, where they become rare. In Missouri it is found everywhere in suitable localities.

Habits.—The Blue Racer was quite common some twenty years ago in pastures, meadows and fields, but as cultivation has advanced on these places their haunts have been destroyed. Most farmers kill them when they find them in their fields, although the Blue Racer is the farmer's best friend in destroying rats, mice, moles, etc. Even if they occasionally take a young chicken or an egg their usefulness far outweighs this small damage.

The name "Racer" is well given, as they certainly slide away with great rapidity. As to their following a frightened person I cannot testify, but if one of them is cornered it will defend itself with astonishing courage.

When driven to bay, its tail will quiver with rage, making quick vibrating motions, which, among dry leaves, will produce sounds not unlike the whir of the Rattle Snake. May 1, 1898, I caught a Blue Racer just swallowing a Copper-head about two feet long. The victim had about half disappeared when I took hold of the Black Snake. Before I had time to get it into my bucket it had disgorged the Copper-head, which recovered. It is astonishing how quickly one of these snakes entangles its victim. In the twinkle of an eye it has wrapped itself around the coveted morsel. It makes two or three coils, then a squeeze, and the victim is dead. The snake looks for the head and begins to swallow it, releasing its coils as the swallowing progresses.

Dates of capture.—April 8, 15, 22, 27; May 1, 6; July 13; Oct. 3.

59. BASCANION CONSTRICTOR FLAVIVENTRIS Say. Yellow-Bellied Racer.

Bascanion flaviventris, Zamenis flaviventris var. B., Zamenis constrictor flaviventris, Coluber flaviventris, Coluber constrictor flaviventris, Coryphodon flaviventris, Coryphodon constrictor vetustus, Bascanium constrictor vetustum, Bascanion vetustus, Zamensis stejnegerianus.

Description.—Rostral large, about as high as wide, hollowed below and bounded behind by internasal, anterior nasal, and first labial. A pair each of internasals and prefrontals. Frontal long and narrow. A pair of large parietals. Anterior and posterior nasal distinct, nostril in the anterior one. Loral quadrangular. Preoculars normally two but sometimes united. Postoculars two, upper one a little larger than lower. Temporals 2-2, 2-3, or 1-2. Seven or eight upper labials, third and fourth or fourth and fifth entering the eye, sixth and seventh the largest. Eight or nine lower labials, four, in contact with the anterior chin shield, are about equal.

Head rather long, with flattened top, rounded snout. Dorsal scales smooth, in seventeen rows. Ventrals 163-179. Anal divided. Subcaudals 79-98 pairs.

Color.—The color above in adults is green, olive or reddish-brown, changing to green on the lower rows of scales and on the tips of the ventrals. Head and tail unicolor with the body. Beneath yellow, unspotted.

Habitat.—From Missouri west to the Pacific Coast. Missouri localities:—Crawford, Stone, and Jasper Counties.

Habits.—So far I have only received this species from the Ozark Plateau, but have never found one myself. Hence I can say nothing concerning its life history.

60. Bascanion flagellum Shaw. Coach-Whip Snake.

Bascanion flagellum flagellum, Bascanium flagelliforme, Bascanium flagelliforme flagelliforme, Bascanium flagelliforme testaceum, Bascanion flagelliforme, Bascanium flagelliforme bicinctum, Bascanium piceum, Zamensis flagellum, Zamensis flagellum flagellum, Zamensis flagelliformis, Bascanium flagelliforme piceum, Zamensis flagellum piceus, Zamensis flavigularis, Masticophis flagelliformis, Masticophis flagelliformis testaceus, Masticophis testaceus, Masticophis flavigularis, Herpetodryas flagelliformis, Herpetodryas flavigularis, Herpetodryas psammophis, Psammophis flagelliformis, Psammophis flavigularis, Natrix flagelliformis, Natrix mycterizans, Natrix filiformis, Coluber flagellum, Coluber filiformis, Coluber mycterizans, Coluber flagelliformis, Coluber flagelliformis testaceus, Coluber testaceus, Anguis flagelliformis.

Description.—Snout projecting. Rostral nearly as deep as broad, well visible from above and excavated below. Internasals small, anterior margin convex. Prefrontals narrow behind, wide in front, the outer posterior angle just meeting the anterior angle of the superciliaries. Frontal narrow behind, one and one-fourth as long as broad, equal to its distance from the end of the snout. Superciliaries broad, pointed in front. Parietals a little longer than the frontal, and wide. Anterior nasal larger than the posterior, with the nostril between them. Loral one. Anteorbitals two, lower one small. Postorbitals two. Upper labials eight, fourth and fifth entering the eye, fifth and seventh the largest. Lower labials nine, fifth the largest. Four labials in contact with the anterior chin shield. Posterior chin shield as long as or a little longer than the anterior. Head distinct from the body. Eyes large, body and tail very long and slender. Dorsal scale rows seventeen, smooth. Ventrals obtusely angulate, 182-211. Anal divided. Subcaudals 80-112 pairs.

Color.—The color above is yellowish to dark brown, and much darker anteriorly. Lower labials occasionally with white streaks or dots. Belly yellowish, shaded with dusky on the posterior edge of the ventrals. These shades become wider towards the sides.

A specimen with two lorals on each side, a fine male, has the posterior of the back pinkish, with the same color, even more intense, on the belly. Younger specimens have a reddish brown color with cross bands on the back. The anterior part of the belly is yellowish, with

two triangular dark spots on each ventral. The rest of the belly is yellowish shaded dusky like the adults. Upper and lower labials and chin shields yellow with blackish spots. Top of head light brown.

Size.—Total length 1700 mm. Tail 380 mm.

Habitat.—From South Carolina to Florida, and west of the Mississippi to Arkansas and Missouri in the Ozark plateau. Missouri localities:—Jefferson, Wayne, Oregon, Ozark, Stone, and Phelps Counties.

Habits.—The Whip-Snake, as it is commonly called, is rather rare in Missouri. It is exceedingly swift. They occur on top of hills as well as in valleys. Their food consists of small rodents, such as mice and rats, birds and eggs. When annoyed they vibrate the tail rapidly, opening the mouth partially. With the head raised some distance from the ground they strike viciously and repeatedly, but, on account of their short teeth, cannot inflict serious wounds. In disposition it is much like the Blue Racer. The species is oviparous.

Genus PITUOPHIS.

Maxillary teeth smooth, of equal length. A vertical laminiform epiglottis. Cephalic scuta normal, except that each prefrontal is longitudinally divided into two, producing four prefrontals. Rostral plate more or less prominent, and its superior angle produced upward and backward between the internasals. Scales more or less keeled with pits. Anal scuta entire; subcaudals in two series. Pupil round, large. (Cope.)

61. PITUOPHIS SAYI Schlegel. Bull Snake. Western Bull Snake. Pine Snake.

Pityophis sayi, Pityophis sayi sayi, Pityophis catenifer sayi, Coluber sayi.

Description.—Snout projecting. Rostral very high, wedged between the internasals, sometimes reaching the prefrontals. Prefrontals 3 to 7. Frontal one and one-third to one and two-thirds as long as broad, as long or a little longer than its distance from the rostral. Superciliaries broad behind, narrow in front. Parietals broken up into small plates posteriorly. Internasals rounded in front, separated by the rostral. Nasals two, anterior larger, nostril mostly in the posterior one. One loral, longer than deep, small. One preorbital, sometimes with a small one below. Two or three postorbitals and one or

two postsuborbitals. Temporals 3, or 4-4, or 5. Upper labials eight to ten; fourth or fifth entering the eye, seventh and eighth the largest. Lower labials ten to thirteen; seventh the largest. Anterior chin shields very large, posterior very small. Five or six labials in contact with the anterior chin shield.

Head pointed, eyes large, neck slightly constricted. Body large and strong. tail short and slender. Dorsal scales in 27-33 rows, keeled, with the exception of the first five or ten rows. Ventrals 220-240. Anal entire. Subcaudals 45-60 pairs.

Color.—Color above from yellowish white to reddish brown, with a dorsal series of large black or brown spots, and with two or three series of smaller spots on each side. Beneath yellow, more or less blotched with black. A black bar, arched forwards, generally extends from orbit to orbit across the head. Labials more or less widely edged with black. (Garman.)

Size.—Total length 1480 mm.; tail 187 mm.

Habitat.—This species occupies the entire interior of the United States and the Mexican plateau to the valley of Mexico. Eastward it crosses the Mississippi River into the prairies of Illinois. Missouri localities:—Phelps, Taney, Stone, and Jasper Counties. In Illinois, St. Clair and Madison Counties.

Habits.—The Bull Snake is rather scarce in this state. I have never found one myself. Mr. J. C. Miles of Carthage, Mo., sent me one which had been kept for some time at the High School of Carthage, where it had been teased so much that it acquired a very ill temper and could hiss remarkably loud and long. It sounded like an engine blowing off steam. While hissing it would vibrate its tail rapidly like a Rattle Snake. It did not eat in captivity.

The food of the Bull Snake consists of rabbits, rats, mice, birds, and eggs. Ditmars gives a very interesting account of the voracity of one of these snakes. "The Bull Snake swallowed fourteen hen's eggs, breaking the shell of each after the egg had passed about a foot down the throat. The demonstration closed by the supply of eggs becoming exhausted and not from any indifference on the reptile's part."

The Bull Snake is oviparous, the eggs yellowish white with a tough leathery shell. It is the largest snake found in this state.

Genus HETERODON.

Posterior maxillary teeth much enlarged, solid. Rostral plate very high, with upturned edges, anterior face flat. An azygous plate behind the rostral. Scales keeled, in twenty-five rows. Anal plate divided. Subcaudals in two series.

62. HETERODON PLATIRHINOS Latreille. Blowing Adder. Spread Head. Spreading Viper.

Heterodon tigrinus, Heterodon annulatus, Coluber thraso, Heterodon platyrhinus, Coluber cacodaemon, Coluber heterodon, Anguis capito viperino, Boa contortrix.

Description.—Rostral plate triangular, point produced upwards, slightly recurved, anterior margin sharp, keeled above. Azygous plate elongate, bounded anteriorly by the rostral, at the sides by the internasals and posteriorly by the prefrontals. Internasals triangular, with the apex pointing forward. Prefrontals wider than long. The azygous plate extending half way between the prefrontals. Nasals two. Nostril valvular, situated between the two nasals. Loral small, higher than long. Orbitals nine to eleven. Temporals 3-4 or 4-4. Upper labials eight, the seventh the largest. Lower labials nine to ten. Anterior chin shields two. Posterior four and small. Three lower labials in contact with the anterior chin shield. Head large, short and broad. Snout recurved. Eyes large. Mouth cleft, large, and much curved. Body stout, tail very short, tapering rapidly. Dorsal rows of scales twenty-five, all distinctly keeled, with the exception of the two or three outer rows, of which the first is smooth and the other two only obscurely keeled. Ventrals 120-150. Anal divided. Subcaudals 43 to 60 pairs.

Color.—Color above brown, with a dorsal series of dark quadrate blotches, separated by interspaces of one or two scales. Margin between blotches frequently white. Smaller dark oval to round blotches alternate with the dorsal. Two large black blotches on the nape. Top of head brown. A dark line across the prefrontals and anteorbitals joins the anterior angles of the orbits. Another black line across the superciliaries and the base of the frontals, joining the posterior angle of the orbits. The snout is much lighter brown than the top of the head. Upper labials yellowish, minutely dotted with dark brown on the upper edge. Lower labials, chin and throat yellowish. Belly greenish tc yellowish, often clouded with blackish, which color often predominates on the posterior part of the abdomen. Lower side of tail yellow.

Size.—Total length 780 mm.; tail 115 mm.

Habitat.—From Pennsylvania to Florida west to Minnesota and south to Texas. Missouri localities:—St. Louis, Jefferson, St. François, Washington, Shannon, Oregon, Howell, Stone, Jackson, Gasconade, Crawford, Franklin, St. Charles, Warren, Montgomery, Pike, Lewis, and Randolph Counties. In Illinois, St. Clair, Madison, Monroe, and Randolph Counties.

Habits.—The Blowing Adder is a clumsy looking snake, much feared by the farmers, who can hardly be persuaded that it is not poisonous. It lives near springs and creeks, where it finds its food—toads and frogs. When disturbed it flattens out its head and the anterior part of the body, giving it quite a dangerous appearance. It hisses loudly, from which fact it takes its name "Blowing Adder." When teased it often feigns death, turning on its back and remaining motionless for quite a while. It repeats this operation as long as there is danger or it is being tormented. Specimens that I had in captivity laid a number of eggs, 31 mm. long by 18 mm. diameter.

Dates of capture.—April 12, October 14.

Melanistic Variety of Heterodon platirhinos.

Heterodon niger, Scytale niger, Vipera nigra.

Description.—Same as for *Heterodon platirhinos.*

Color.—The color above is dark brown to black, beneath dirty white to yellowish. The lower side of the tail is always yellow. Sometimes the faint markings on the back of *H. platirhinos* can be perceived.

Habitat.—Same as for *H. platirhinos.* Missouri localities:—Stone, Howell, Jackson, and Crawford Counties, and in Illinois Madison County.

Habits.—Same as for *H. platirhinos.* I have never found a dark young specimen. The variety is oviparous. The eggs are 30 mm. long by 18 mm. diameter.

Genus elaphe.

Maxillary teeth 12 to 22, subequal in size. Anterior mandibular teeth the longest. Head distinct from the neck, elongate. Eye rather large.

Nasals two. Loral present, anteorbital one, postorbitals two. Dorsal scales with pores, keeled along the back, smooth on the sides (the carinations sometimes obsolete), 25 to 29 rows. Ventrals rounded or angulate laterally. Anal divided. Subcaudals in two rows. Tail moderate or long. This genus includes the largest and most active snakes.

Key to Missouri Species.

Scales in 25 rows (rarely 23 to 27), 9 to 11 feebly keeled. *vulpinus.*

Scales in 27 rows (rarely 29), obsoletely keeled. Reddish with brick-red blotches. *guttatus.*

Scales in 27 rows (rarely 25-29), seven outer rows smooth. Blackish above with darker blotches. *obsoletus.*

Scales in 27 rows, outer rows smooth. Yellowish to brown, with black blotches. *confinis.*

Scales in 27 rows. *spiloides.*

Scales in 29 rows. Light gray with brown blotches. *emoryi.*

63. Elaphe vulpinus Baird and Girard. Fox Snake.

Coluber vulpinus, Scotophis vulpinus, Scotophis guttatus var. vulpinus, Elaphis guttatus var. vulpinus, Elaphis rubriceps.

Description.—Rostral broader than deep, the portion visible from above measuring one-third its distance from the rostral. Internasals broader than long, shorter than the prefrontals. Frontal as long as broad, as long as its distance from the rostral, shorter than the parietals. Nasals two, nostril between the two. Loral as long as deep. One pre- and two post-oculars. Temporals 2-3. Eight upper labials, third and fourth or fourth and fifth entering the eye; seventh the largest. Five lower labials, sixth the largest. Five lower labials in contact with the anterior chin shields, which are longer than the posterior. Head large, distinguished from the neck. Eyes rather small. Dorsal rows of scales 25 (rarely 23 to 27). Anteriorly the first three or four rows are smooth, then they are obsoletely keeled, more so toward the back, although everywhere moderately so. Body slender. Ventrals 200-234. Anal divided. Subcaudals 65 to 85 pairs. Ventrals and subcaudals less numerous than in any other of the genus *Elaphe.*

Color.—Color above grayish yellow or brownish, with a dorsal series of large chestnut brown blotches. Two lateral series of smaller blotches, alternating with the dorsals. Head light brown, with indistinct darker markings. Two dark stripes along the occiput and nape. Beneath yellowish, alternating with square dark blotches.

Size.—Total length 960 mm. Tail 200 mm. Sometimes they reach a length of 1500 mm. and over.

Habitat.—The Fox Snake is more of a northern species,

being recorded from Ontario, Michigan, Minnesota, Indiana, Illinois, Nebraska, Kansas, and Missouri. I have never found one south of the Missouri River. Missouri localities:—Dardenne Prairie in St. Charles County.

Habits.—The Fox Snake is a ground snake and is quite rare. The only living specimen I ever captured I obtained April 22, 1900, at Elm Point, St. Charles Co. That same day I picked up two dead ones about two miles from there.

64. ELAPHE GUTTATUS Linnaeus. Spotted Coluber. Spotted Racer. Corn Snake. Red Chicken Snake. Mouse Snake.

Coluber guttatus, Scotophis guttatus, Elaphis guttatus, Elaphis rubriceps, Coluber pantherinus, Coluber carolinianus, Coluber maculatus, Coluber floridanus, La Tachettée.

Description.—Rostral broader than deep, just visible from above. Internasals broader than long, much shorter than the prefrontals. Frontal once and a half to once and two-thirds as long as broad, as long as its distance from the end of the rostral, shorter than the parietals, which are rather narrow. Nasals two, nostril in the suture between them. Loral longer than deep, one pre- and two post-oculars. Temporals two or 3-3. Eight upper labials, fourth and fifth entering the eye, seventh the largest. Eleven lower labials, sixth the largest. Four or five lower labials in contact with the anterior chin shields, which are as long or a little longer than the posterior. Head elongate, body elongate. Tail shorter than in any of the genus, except the preceding one. Dorsal rows 25, 27, or 29, faintly keeled, sometimes smooth. Ventrals 200-239, obtusely angulate laterally. Anal divided. Subcaudals 60-88.

Color.—Color above yellowish or pale brown, with a dorsal series of large red, black-edged blotches, and an alternating lateral series of smaller spots. A dark curved band from eye to eye across the frontal, continued behind the eye to the angle of the mouth. A, U or O shaped marking from the frontal shield to the nape. Labials usually with black sutures or spots. Belly yellowish with large black square blotches. Under the tail a whitish streak along the middle of the subcaudals.

Size.—Total length 1040 mm.; tail 160 mm.

Habitat.—The Spotted Racer ranges over the southern half of the eastern United States to the Mississippi River, and west to Arkansas and Missouri.

Habits.—Dr. S. E. Meek of the Field Museum of Natural History reports this snake from Greenway, Clay Co., Arkansas. Clay County is just west of Dunklin County, Mo., and as the environments are the same, I do not doubt that eventually the Spotted Snake will be found in Missouri.

65. ELAPHE OBSOLETUS Say. Black Snake. Pilot Snake. Mountain Black Snake. Rat Snake.

Coluber obsoletus, Coluber obsoletus obsoletus, Scotophis obsoletus, Coluber alleghaniensis, Scotophis alleghaniensis, Elaphis holbrookii, Elaphis alleghaniensis, Georgia obsoleta, Spilotes obsoletus, Elaphis obsoletus.

Description.—Rostral broader than deep, just visible from above. Internasals broader than long, much shorter than the prefrontals. Frontal a little longer than wide, as long or a little shorter than its distance from the rostral, shorter than the parietals. Nasals two, nostril in the suture between. Loral longer than deep. One pre- and two postoculars. Temporals 2-3. Eight upper labials, seventh the largest, fourth and fifth entering the eye. Lower labials eleven or twelve, sixth or seventh the largest. Four or five lower labials in contact with the anterior chin shields, which are as long as the posterior. Dorsal rows of scales 25 or 27, sixteen keeled. Ventrals 224-246. Anal divided. Subcaudals 75-90.

Color.—The color above black or very dark brown, the dorsal spots indistinctly outlined, but enough to make them out. In young and newly shed specimens they are well marked. In some individuals the skin on the side is more or less red. The belly is usually slaty black behind, yellow anteriorly, more or less maculated with black blotches. Throat and chin white. Labials the same, margined with black.

Size.—Total length 1850 mm.; tail 320 mm.

Habitat.—Massachusetts to Kansas and Nebraska, southwest to Texas. Rare in Florida. In Missouri the Black Snake is found everywhere, but especially in wooded districts.

Habits.—The Black Snake reaches a greater size than any other of our snakes. It hides in hollow logs and holes of trees. July 24, 1898, while out hunting, I discovered one on a heavy limb of a large sycamore tree at least sixty feet from the ground. I shot it down and found it

measured over five feet. Another time I caught one feasting on Yellow Hammers. This snake swallows hen's eggs entire, not crushing them when partly down the throat. I have an egg which I dissected out of a snake. The lower end is softened by the action of the gastric juice but the forward end is still intact. Dr. G. B. Goode includes this snake among those which are said to "swallow their young," i. e., when danger appears the mother allows her young to crawl down her throat for safety. I have never seen this done. Black Snakes feed on rabbits, rats, mice, quail, and other birds. Like many other snakes the Black Snake vibrates its tail, making a rattling or whirring sound. The species is oviparous. One I had in captivity laid nineteen eggs, none of which, however, contained an embryo. The eggs were cylindrical with spherical ends, some 60 mm. long and 22 mm. in diameter.

Dates of capture.—April 4, 8; June 25; July 8, 24; Sept. 1.

66. Elaphe confinis Baird and Girard. Gray Coluber. Gray Rat Snake. Spotted Chicken Snake.

Coluber confinis, Coluber obsoletus confinis, Scotophis confinis, Scotophis laetus, Coluber laetus, Coluber rosaceus.

Description.—Rostral slightly projecting, little visible from above. Internasals much smaller than the prefrontals. Frontal rather longer than wide, a little longer than its distance from the end of snout. Parietals large, truncate behind. Loral small. One preocular, two post-oculars. Temporals 2-3. Upper labials eight, seventh the largest, fourth and fifth entering the eye. Eleven lower labials, fifth the largest, four in contact with the anterior chin shields, which are longer than the posterior. Dorsal scale rows 27 (occasionally 28), 11 or 13 slightly keeled. Ventrals 231-258. Anal divided. Subcaudals 75-96 pairs.

Color.—Color above yellowish gray or ashy, with dark brown spots, narrowly margined with black, five or six scales long, and from thirteen to fifteen wide; longitudinally quadrate in shape, interspaces about two scales long. On the second to the fifth rows the lateral spots are elongated and exhibit sometimes a disposition to form an indistinct stripe. Belly yellow, clouded posteriorly, and with dark spots on the ends of the ventrals and the outer scale rows; a dark post-ocular stripe, some indistinct mottling on the borders of the labials.

Habitat.—From Virginia south to Florida, west to Texas, north to Missouri. Missouri localities:—St. Louis and Montgomery Counties.

Habits.—I have found the Chicken Snake quite scarce in Missouri. My friend, Mr. E. M. Parker, presented me with a fine half grown specimen from Montgomery Co. Ditmars says "All the Colubers show a great fondness for eggs and swallow them entire, but as the eggs pass about fourteen inches down the reptile's neck, that portion of the body is pressed against the ground and by a strong steady contraction of the swallowing muscles, the shell of each egg is broken and the fragments are swallowed together with the contents of the eggs and are digested." My own observations do not agree with this. Whenever I found a snake that had swallowed an egg I always found the egg entire in the stomach, where the shell had been softened by the gastric juice. Chicken Snakes feed on rabbits, rats, mice, birds, young chickens, and eggs. Like many other snakes this one emits a very offensive secretion from glands at the end of the tail when overpowered. This secretion is white and viscid. The species is oviparous.

67. ELAPHE SPILOIDES Dumeril and Bibron.

Elaphis spiloides, Coluber spiloides, Coluber obsoletus var. spiloides.

Description.—Rostral broad. Internasals small. Prefrontals long and broad. Frontal as long as broad or a little longer. Superciliaries twice as wide posteriorly as anteriorly. Parietals long, broad, truncate behind. Lorals slender, pointed posteriorly. Anteorbital one, postorbitals two. Temporals 2-3. Upper labials eight, fourth and fifth entering the eye, seventh the largest. Lower labials fourteen, eighth the largest, five in contact with the anterior chin shields, which are much longer than the posterior. Dorsal scales in 27 rows, fifth to eleventh faintly keeled. Ventrals 218-244. Anal divided. Subcaudals 80-96 pairs. Head distinct from the body. Tail short and slender.

Color.—Color above ash gray. A dorsal series of about forty-five blotches; anterior blotches about 13 scales wide by 6 scales long; posterior slightly shorter. Most of these blotches are rhomboidal. Alternating with these dorsal blotches is a series of elongated lateral ones

of the same color as the dorsal. Anteriorly two or three of these spots may coalesce, forming a narrow stripe. On the margin of the ventrals is a series of small square brown spots. Belly whitish with black blotches. Chin and throat white. Four or five lower labials, with black marks. A black stripe from the orbit to the angle of the mouth and one crossing the labials below the eye. Top of head brown. A black stripe crossing the base of the prefrontals and connecting orbits.

Habitat.—Texas, Oklahoma, Kansas, Western Missouri.

Habits.—So far I have never found this snake in Missouri, but include it in my list on the report of Cope in the Report of the United States National Museum, Vol. 20, page 843, where he reports it from Independence, Jackson Co., Mo. Two years ago I bagged several near Brownsville, Cameron Co., Texas. At San Antonio, Texas, Dr. Bock, who was with me on this trip, found one on top of a small tree trunk. The snake had swallowed two eggs, which could be distinctly felt in the stomach. As we were ready to leave for New Braunfels, I put the snake in my collecting bucket. On arriving I found that the snake had disgorged the two eggs—guinea eggs. One of them had only lost the spots at one end but was otherwise entire. The other one looked like a piece of yellowish well soaked leather. It no longer had the shape of an egg, but had not been broken as I blew it up to its original shape. Very little of the contents were left.

68. Elaphe emoryi Baird and Girard. Emory's Snake.

Coluber emoryi, Coluber guttatus var. emoryi, Scotophis emoryi, Scotophis calligaster, Coluber rhinomegas.

Description.—Frontal longer than broad. Loral elongated, acute angled behind. Anteorbital large. Two postorbitals resting on the fifth labial. Temporals 2-3. Upper labials eight, sixth and seventh the largest, fourth and fifth entering the eye. Lower labials eleven, sixth the largest, four in contact with the anterior chin shields, which are longer than the posterior. Head rather narrow. Eye large. Dorsal rows 27-29, smooth except traces on the central five or six in some individuals. Exterior row largest, rest nearly equal. Ventrals 211-236. Anal divided. Subcaudals 63-76 pairs.

Color.—Ground color pale gray, with a dorsal row of brown blotches with black borders, ten or twelve scales wide and three or four long, separated by interspaces of one and one-half to two scales long. A second series of smaller alternating spots from the third to the seventh rows, subcircular in shape. A third indistinct series on the second and third rows, and a fourth indicated on the outer row and the ends of the ventrals. Belly yellowish or white, with irregular ashy blotches posteriorly. Top of head much banded. A dark oblique post-ocular stripe.

Size.—Total length 796 mm.; tail 163 mm. Total length 1330 mm.; tail 190 mm.

Habitat.—Arkansas, Missouri, Kansas, Oklahoma, and Texas. Missouri localities:—Jefferson and Stone counties.

Habits.—This species is rather rare. So far I have only found it on the southern slopes of the Ozark plateau. Its food consists of mice, etc. It is generally found under rocks. I once caught one in a house.

Genus LAMPROPELTIS.

Maxillary teeth smooth, slightly increasing posteriorly, but not separated by an interspace. One loral, two nasals, one preocular, two postoculars. Scales smooth, with two pores each, in 19 to 25 rows. Anal entire.

Key to the Species in Missouri.

Scales in 21 rows. Ground color reddish or gray, with 40 to 50 chocolate or brown saddle-shaped blotches, which are bordered with black. *doliatus.*

Scales in 21 to 23 hows. Size large Black with centers of scales white or yellowish. These sometimes form transverse rows of spots. *getulus.*

Scales in 25 rows. Grayish brown with from 40 to 60 dark blotches above. Belly blotched. *calligaster.*

69. LAMPROPELTIS DOLIATUS Linnaeus. House Snake. Milk Snake. King Snake.

Coluber doliatus, Coronella doliata, Ophibolus doliatus, Ophibolus doliatus doliatus, Ophibolus doliatus triangulus, Osceola doliata, Osceola doliata doliata.

Description.—Rostral wider than high. Nasals two, nostril mostly between the two. Loral one, a little longer than high; one anteorbital;

two postorbitals. Frontal as long as broad or a little longer, as long as its distance from the end of the snout, a little shorter than the parietals. Temporals 2-3. Seven upper labials, third and fourth entering the eye. Nine lower labials, fifth the largest, four in contact with the anterior chin shields, which are much longer than the posterior. Scales in 21 rows, smooth. Ventrals 200 to 210. Anal entire. Subcaudals 45 to 55 pairs.

Color.—Ground color grayish white or yellowish. Dorsal saddle-shaped blotches brownish or red with black borders. They do not reach to the ventrals. Belly whitish or yellowish with black blotches. The dorsal blotches sometimes form nearly parallel black bands on the center part across the back.

Size.—Total length 655 mm.; tail 95 mm.

Habitat.—Maryland to Florida, west to Texas, Oklahoma, Kansas, Missouri, Illinois, Indiana, and Tennessee. Missouri localities:—St. Louis, Jefferson, Washington, Oregon, Howell, Stone, Jasper, Jackson, Gasconade, St. Charles, Montgomery, and Warren Counties. In Illinois, St. Clair and Randolph Counties.

Habits.—The Milk Snake is often accused of sucking the milk from cows, from which fact it takes its common name. In all my experience I have never found anyone who had really seen it done, nor have I myself ever witnessed it. While this snake makes its home around spring houses it does so to be near its food—rats and mice. The Milk Snake is a cannibal, swallowing its own kind and other small serpents and lizards. The first Milk Snake I found was hiding under the loose bark of heavy rotten log. I placed it in my collecting bucket with a lizard, *Eumeces fasciatus.* On looking into the bucket a little later I found only a small end of the lizard sticking out of the snake's mouth and the wriggling tail, which had been broken off in the struggle, at the bottom of the bucket.

Dates of capture.—April 4, 12, 15; May 2, 24; July 4, 14; October 4; November 8.

70. LAMPROPELTIS GETULUS HOLBROOKI Stejneger.[5] King Snake. Salt and Pepper Snake.

Lampropeltis sayi, Ophibolus getulus sayi, Ophibolus sayi, Coronella sayi, Coronella getulus var. sayi, Coluber sayi, Ophibolus getulus.

Description.—Rostral triangular, little visible from above. Internasal quadrate, smaller than prefrontals, which are large and wider than long. Frontal a little longer than wide. Superciliaries shorter than the frontal. Parietals longer than frontal, truncate behind. Nasals two. Loral one, small. One pre- and two post-oculars. Temporals 2-3. Upper labials seven, third and fourth entering the eye, fifth and sixth the largest. Lower labials nine, fourth and fifth the largest, four in contact with the anterior chin shields, which are twice as long as the posterior. Scales smooth, in 21 rows. Ventrals 200 to 220. Anal entire. Subcaudals 40 to 60 pairs.

Color.—Above dark brown to bluish black, each scale with a yellow or white spot. On the sides these spots cover more than half the scales. In young specimens the spots form narrow cross bands over the back. These bands persist often in the adult. Beneath yellowish white, checkered with bluish black, which markings follow the scales and are more numerous on the posterior part of the body. Each plate of the head has one or more spots of yellow. The rostral is yellowish with black borders on top. Lower labials yellow bordered with black.

Size.—The largest specimen I ever found in Missouri was 1270 mm. long.

Habitat.—Nebraska, Kansas, Missouri, Illinois, Southern Indiana, south to Mississippi, Louisiana, and Texas. Missouri localities:—St. Louis, Jefferson, Oregon, Howell, Stone, Phelps, Crawford, Montgomery, and St. Charles Counties. In Illinois, St. Clair County.

Habits.—The King Snake is not found often in Missouri. It inhabits hilly places with sunny glades, occurring under rocks and fallen trees. Its food consists of mice, small birds, lizards and snakes. If a King Snake meets a small Rattle snake or Copper-head it starts a quarrel and coils itself around its victim's body. Biting will be of no avail as the King Snake is immune to snake poison, but only enrages the agressor. The victim is

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[5] Proc. U. S. Nat. Mus. **25:** 152. 1903.

finally strangled. The King Snake is a very useful snake for the farmer, destroying many injurious rodents.

Ditmars in his Reptile Book says:—"While the majority of snakes quickly succumb to an injection of serpent poison, the King Snake may be repeatedly wounded by the fangs of a living serpent, or injected hypodermically, without showing ill effects from the introduction of the formidable fluid into its blood. Some three years ago, repeated experiments were conducted upon a large specimen that is now thriving. It was injected with the venom of the diamond-back rattle snake, the copperhead snake, the moccasin and the West Indian "fer-de-lance," without showing any bad effects beyond an intimation of sluggishness appearing an hour or so after the injection and entirely passing away several hours later."

In 1891 Mr. Arthur Erwin Brown, Director of the Zoological Garden in Fairmont Park, Philadelphia, sent me a King Snake, *Lampropeltis getulus,* from Florida. While I had this snake my son brought home a Black Snake, about five feet long, putting it in the cage with the King Snake. The next morning—not knowing about the snake my son had brought home—I found the King Snake, which was only four feet long, curled up in the shape of a horse shoe. It was perfectly rigid, only showing signs of life by moving its tongue. I thought the snake was sick. Later in the day I learned the true state of affairs. The four foot King Snake had swallowed the five foot Black Snake. The tail of the victim was bent over in the neck of the King Snake, making it resemble a Cobra very much. It took the snake an entire week to digest its prey. During this week it was harmless and almost liveless. Toward the end it became pliable again and as lively as ever.

Dates of capture.—April 2, 4, 15, 26; May 13; June 20; October 1.

71. LAMPROPELTIS CALLIGASTER Harlan. Evans' King Snake. Yellow-bellied King Snake. Brown King Snake.

Coluber calligaster, Coluber guttatus, Ophibolus evansii, Coronella evansii, Coronella tigrina, Coronella calligaster, Ophibolus calligaster, Ophibolus triangulus var. calligaster, Ablades triangulum var. calligaster.

Description.—Rostral about once and a half as broad as deep. The median suture between the internasals shorter than that between the prefrontals. Rostral a little longer than broad, shorter than the parietals. Nasals two. Loral longer than deep. One pre- and two postoculars. Temporals 2-2 or 2-3. Upper labials 7 or 8, third and fourth entering the eye, sixth the largest. Lower labials nine, fifth the largest, the first pair meeting at the median line, four in contact with the anterior chin shields, which are longer than the posterior. Snout scarcely prominent. Eye rather small. Tail one-seventh of the total length. Scales in 25 rows, smooth, the outer row the widest. Ventrals 198-215. Anal entire. Subcaudals 40 to 57 pairs.

Color.—Above light olivaceous-brown or gray, with a dorsal series of subquadrate blotches, dark brown with narrow black border, the blotches two to three scales long, eight to ten wide. A smaller alternating series on the sides, which often form irregular vertical bars, and a third on the outer row of scales and ends of ventrals. Belly yellowish with or without black blotches in the center. The top of the head is sometimes very elaborately marked. Labials yellow. An elongated brown blotch with black border on each side, running back from the parietals to the neck. All these markings are in older specimens nearly indistinct, but young specimens show the markings nicely. The general aspect of the snake is very much like *L. rhombomaculatus* of the Southeastern States, but it has 25 rows of scales instead of from 21 to 23.

Size.—Total length 1180 mm.; tail 165 mm.

Habitat.—Indiana to Minnesota, southwest to Nebraska, Kansas and Texas. Missouri localities:—St. Louis, St. Charles, Jefferson, Jasper, and Montgomery Counties. In Illinois, Madison County.

Habits.—Evans' King Snake lives upon small rodents, frogs, lizards, and small fish. It is generally found in prairies and pastures. It is oviparous. In captivity it takes no food. The King Snakes are all constrictors. My first specimen I received from my friend, Dr. Eugene Bri-

bach, who picked it up from the furrows in a plowed field, at Highland, Madison Co., Ill.

Dates of capture.—April 2, 22, 24, 29; May 26; September 9.

Genus DIADOPHIS.

Head sub-elliptical, elongated, depressed, distinct from the body. Cephalic plates normal. Two ante- and two post-orbitals. One loral. Two nasals, nostril between them. Eyes large. Mouth deeply cleft. Body slender. Dorsal scales smooth, in 15 to 17 rows. Anal divided. Subcaudals in pairs.

72. DIADOPHIS REGALIS ARNYI Kennicott. Ring-necked Snake.

Diadophis regalis, Diadophis arnyi, Diadophis punctatus aryni.

Description.—Rostral wider than high. Nasals two, nostrils in suture in the anterior one. Upper labials seven, third and fourth entering the eye, sixth the largest. Temporals 1-1. Lower labials eight, fifth the largest, five in contact with the anterior chin shields, which are nearly twice as long as the posterior. Dorsal scales in 17 rows, smooth, with one pit. Ventrals 160. Anal divided. Subcaudals in 50 pairs. Head depressed, little distinct from the body. Tail short.

Color.—Above uniform leaden or olive brown to black. A yellow band across the base of the head, one to two scales wide. Beneath yellowish or reddish yellow and still redder under the tail. Thickly and irregularly spotted with black on the whole ventral surface.

Size.—Total length 310 mm.; tail 51 mm.[6]

Habitat.—From Illinois, Missouri, Kansas, south to Arizona and Mexico. Missouri localities:—St. Louis, Jefferson, Washington, Iron, Butler, Stone, Jasper, Gasconade, Crawford, Jackson, Randolph, and Montgomery Counties. In Illinois, St. Clair County.

Habits.—The Ring Snake is rather common but never found outside of its cover. It occurs mostly under rocks and logs. I once found one in the mold inside of a rotten tree stump. Another time on turning over a rock, about

[6] This species is the largest of the genus *Diadophis*.

2 feet by 18 inches, I found 17 specimens. (May 1, 1898.) The Ring Snake feeds on insects and is oviparous.

Dates of capture.—March 22; April 4, 15; May 2, 6, 21, 24; November 7.

Genus LIOPELTIS.

Head scales normal. Maxillary teeth smooth, equal. Nasal one. Dorsal scales smooth, with one pit. Anal divided. Subcaudals in pairs. Head distinct, size small. Tail long.

73. LIOPELTIS VERNALIS Harlan. Grass Snake. Green Snake.

Cyclophis vernalis, Chlorosoma vernalis, Coluber vernalis, Contia vernalis, Herpetodryas vernalis, Coluber cyaneus.

Description.—Rostral broader than deep, visible from above. Internasals proportionally large, more than half the size of the prefrontals. Frontal elongate, nearly once and a half times as long as broad. Parietals large, truncate behind. One pre- and two post-orbitals. One nasal, with the nostril in the middle. Loral longer than high. Temporals 1-2. Upper labials seven, third and fourth entering the eye, fifth and sixth the largest. Lower labials eight, fifth the largest, four in contact with the anterior chin shields, which are a little shorter than the posterior, and are in contact anteriorly. Head proportionately long, slightly swollen on the temporal region. Snout rounded and projecting over the lower jaw. Mouth cleft, large, and curved. Dorsal scales in 15 rows, smooth, with one pit, the outer row a little broader than the rest. Tail very much tapering, pointed, forming from one-third to one fourth of the total length. Ventrals 125-144. Anal divided. Subcaudals 69-95 pairs.

Color.—Dark green to grass green above, fading on the flanks. Upper lips and lower parts yellowish-white or greenish white. The green changes in alcoholic specimens to blue.

Size.—Total length 510 mm.; tail 160 mm.

Habitat.—Nova Scotia to Wyoming, south and west to New Mexico. Found only rarely in the Southern States. Missouri localities:—Randolph, Jackson, and Johnson Counties. In Illinois, Madison and Monroe Counties.

Habits.—So far I have no record of this snake ever having been captured south of the Missouri River in this

state. Of the two specimens which I have one was captured by Dr. Anton Schaffranek in his garden in St. Charles, and the other by Mr. E. M. Parker of Montgomery City. About thirty-five years ago I picked from a ditch in Madison County, Ill., a dozen specimens. About fifteen years later I returned to the place but did not find any. A farmer, who had been living in that vicinity during the time told me that he had not seen Grass Snakes for many years, although they had been quite common at one time. Grass Snakes feed on insects and caterpillars, but only on the hairless kind. They are oviparous.

Dates of capture.—August 4.

Genus OPHEODRYS.

Maxillary teeth smooth, equal. Cephalic plates normal. One nasal. One loral. One anteorbital. Scales keeled, with two pits. Anal divided. Head distinct from the body. Color green. Tail long.

74. OPHEODRYS AESTIVUS Linnaeus. Green Bush Snake. Rough-scaled Green Snake.

Cyclophis aestivus, Phyllophilophis aestivus, Leptophis aestivus, Leptophis majalis, Liopeltis aestivus, Herpetodryas aestivus, Contia aestiva, Coluber aestivus, Green Snake, Anguis viridis, Anguis gracilis coeruleo viridis.

Description.—Rostral broader than high, well visible from above. Median suture of internasals shorter than between prefrontals; frontal elongate, one and a half times as long as broad, longer as its distance from the end of the snout, shorter than the parietals. Nasal one, with nostril in the center. Loral longer than deep. Anteorbital one; postorbitals two, the lower one small. Temporal 1-2. Upper labials seven, sixth the largest, third and fourth entering the eye. Lower labials eight, fifth the largest, four in contact with the anterior chin shields, which are shorter than the posterior. Head elongate, neck contracted. Snout projecting considerably over the lower jaw. Eyes large. Mouth cleft, large and bent. Body slender, tail whip-like, being usually more than one-third of the total length. Dorsal scales in 17 rows, all keeled except the two outer rows on each side, which are smooth. The scales of the outer rows are also perceptibly wider than the rest. Ventrals 150-165. Anal divided. Subcaudals 111-135 pairs.

Color.—Green above (pea green). The green of the back fades to-

wards the lower rows of scales. Beneath yellowish white. The lower jaw, chin and upper labials whitish yellow.

Size.—Total length 695 mm.; tail 258 mm.

Habitat.—Maryland to Kansas, south to Florida, Texas, and Mexico. Missouri localities:—St. Louis, Jefferson, Wayne, Shannon, Oregon, Ozark, Stone, Jasper, Jackson, Phelps, Crawford, Lewis, Pike, Montgomery, and Warren Counties. In Illinois, St. Clair and Union Counties.

Habits.—The Green Snake may be easily distinguished from the Grass Snake by its keeled dorsal scales and by the number of scale rows, being 17 in the Green or Bush Snake and 15 in the Grass Snake. I have only found this snake on bushes and small trees. It darts at great speed from bough to bough in pursuit of insects. Its green color gives it protection from the birds which prey upon it. Prof. F. W. Putnam found in Massachusetts on August 31st the eggs of this snake under the bark of an old tree stump. They were just ready to hatch, one snake being already out. The eggs were one and a half inches long (38 mm.), and the young a little over five inches (127 mm.).

Genus VIRGINIA.

Maxillary teeth subequal, smooth. One loral, two internasals, no preorbital. Scales smooth, without pits, in 15 or 17 rows. Anal divided. Head distinct. Size small.

75. VIRGINIA ELEGANS Kennicott. Virginia's Snake.

Description.—Rostral narrow, tapering upward. Prefrontals entering the eye and with the loral forming the anterior border of the eye. No anteorbital. Postorbitals two. Temporals 1-2. Parietals large. Upper labials six, third and fourth entering the eye, fifth the largest. Lower labials six, fourth the largest, four in contact with the anterior chin shields, which are equal in length to the posterior. Head small, narrow and relatively high. Snout pointed, eyes small, mouth deeply cleft. Body slender. Tail very short. Dorsal scales in 17 rows, smooth, except those on the tail, which are obtusely keeled. Ventrals 117-126. Anal divided. Subcaudals 29-45 pairs.

Color.—Above the color is light olivaceous brown to pinkish orange. Dull yellowish white beneath. Labials immaculate.

Size.—Total length 300 mm.; tail 65 mm.

Habitat.—Indiana, southern Illinois, Missouri, Arkansas, Louisiana, and Texas. Missouri localities:—St. Louis and Jefferson Counties. In Illinois, St. Clair County.

Habits.—Virginia's Snake is seldom found in Missouri, but this may be due to its secretive habits. All I have found were under rocks. Once I caught one sliding over a narrow path in heavy timbered bottom lands.

Dates of capture.—April 4; May 4, 13; September 6.

Genus FARANCIA.

Maxillary teeth smooth, subequal. One internasal. One nasal, half divided. One loral. No anteorbitals. The loral and postfrontal entering into the orbit. Two postorbitals. Scales smooth, without pits, in 19 rows. Anal plate divided. Size large.

76. FARANCIA ABACURA Holbrook. Hoop Snake. Horn Snake. Sting Snake.

Farancia fasciata, Farancia drummondi, Hydrops abacurus, Hydrops reinwardtii, Helicops abacurus, Calopisma abacurum, Calopisma reinwardtii, Homalopsis reinwardtii, Coluber fasciatus, Coluber ovivorus, La Couleuvre ovivore, Vipera aquatica.

Description.—Rostral wider than deep. One internasal, two prefrontals, reaching down to the orbit. Frontal large, elongate, being one and a half times as long as wide, longer than its distance from the end of the snout, shorter than the parietals, which are very large. Superciliaries proportionately small. One nasal, grooved below the nostril. One loral, which, with the prefrontal, forms the anterior border of the orbit. Two postorbitals, lower one much smaller. Temporals 1-2. Upper labials seven, third and fourth entering the orbit, fifth and sixth the largest. Lower labials eight, fifth the largest, four in contact with the anterior chin shields, which are a little longer than the posterior. Head small, not distinct from the body. Tail short, maintaining its diameter well towards the tip, then tapering suddenly, ending with a conical nail or horn. All the dorsal scales are smooth, in 19 rows, the outer row wider than long. Ventrals 168-206, the one preceding the anal divided. Anal divided. Subcaudals 34-49 pairs.

Color.—Above shining bluish black. Sides and belly red, with transverse, complete or broken, bluish black bands, which are continuous at the sides with downward extensions of the black of the dorsal surface. The red of the ventral surface extends upward on the sides between the black bars to the third or fourth row of dorsal scales.

Since the red has definite margins and contrasts strongly with the black, the belly has a checkered appearance. The head above is of the same color as the back. Upper and lower labials with black dots. The chin shields have also each a black dot.

Size.—Total length 950 mm.; tail 158 mm. Specimens sometimes reach a length of 1400 mm.

Habitat.—The Horn Snake is distributed from South Carolina to Louisiana, and up the Mississippi Valley to Arkansas and the southern part of Missouri, Illinois, and Indiana. Missouri localities:—Butler County. Dr. T. Kingsolving reports it from Hornersville, Pemiscot County.

Habits.—My son found two of these snakes—an adult and a young one—under a log near the water's edge, at Grinnell's Lake, near Poplar Bluff, Butler Co., Mo., April 24, 1898. At the same place he found some more a few years later on April 19th. This is one of the snakes of which such terrible stories are told, giving rise to many popular names, as in this case Hoop Snake, Sting Snake, Horn Snake. I have never yet seen any snake take its own tail in its mouth and roll away like a hoop. This story must have originated in the mind of a very excitable person, probably one that was "seeing snakes." The snake has a very short sharp point on the end of its tail, from which fact it received its name Sting or Horn Snake. The story goes that a sting from this snake means sure death to a person, and death to a tree should it strike with its tail. I have handled this snake many a time. On closing my hand it would make a boring motion with its tail but never succeeded in breaking even the skin.

Genus CARPHOPHIS.

Maxillary teeth smooth, subequal. Rostral normal. Internasals present or absent. Nasal one. Loral large, reaching to the orbit. One postorbital. Scales smooth and glossy, without pits, in 13 rows. Anal divided. Small snakes, with little heads and short tails, terminating in a single acute nail.

77. Carphophis amoenus Say. Worm Snake. Ground Snake.

Coluber amoenus, Celuta helenae, Carphophiops helenae, Carphophis helenae, Celuta vermis, Carphophiops vermis, Carphophis amoena, Carphophiops amoenus, Celuta amoena, Brachyorrhos amoenus, Calamaria amoena, Carphophis vermis, Carphophis amoenus var. vermis.

Description.—Rostral broad. Nasal one, nostril in the anterior half. A large loral, forming with the prefrontal the anterior border of the orbit. Internasals none or two. Postorbital one. Temporals 1-1. Frontal nearly as long as broad. Upper labials five, third and fourth entering the eye, fifth the largest. Lower labials six, fourth the largest, four in contact with the anterior chin shields, which are longer than the posterior. Head very small, snout moderately elongated and rounded. Body glossy, tail short, tapering to a point. Dorsal scales in 13 rows, smooth. Ventrals 112-134. Anal divided. Subcaudals 24 to 26 pairs.

Color.—The color of the back is chestnut brown to light gray and glossy black. Beneath salmon to flesh color (pink).

Size.—Total length 315 mm.; tail 50 mm.

In my description I have included the three varieties: *C. amoenus*, *C. helenae* and *C. vermis*, as I found it rather difficult to make distinguishable characteristics. I have before me 45 specimens:

2. *C. amoenus* from North Carolina.
4 *C. helenae* from east of the Mississippi River.
2 *C. helenae* from west of the Mississippi River.
37 *C. vermis* from west of the Mississippi River.

Separating them:

1st. By the color of the back, I have 6 brown, 8 gray, 31 bluish black. Two of the brown ones are from North Carolina and one each from Mississippi, Kentucky, Tennessee and Illinois. All the gray and black ones are from west of the Mississippi River.

2nd. In regard to the internasals, I find that four from east of the Mississippi River have no internasals, and thirty-nine have one pair of internasals. With the exception of two from North Carolina these are from Missouri and Arkansas.

3rd. By comparing the color of the back reaching to the outer rows, the color reaches in two to the first row, in thirteen to half of the second row, in fifteen to the second row, and in fifteen to the middle of the third row.

All the specimens examined have 1-1 temporals.

Habitat.—The Worm Snake is distributed from Massachusetts to Georgia, west to Arkansas, Missouri, and Kansas. Missouri localities:—St. Louis, Jefferson, Butler, Oregon, Jackson, Montgomery, and St. Charles Counties.

Habits.—The Worm Snake may be common in some localities, but it is seldom seen wandering about. It is found mostly under rocks and decayed logs, under accumulations of damp leaves and mouldy deposits. It is often uncovered in plowing. It feeds upon earth worms and grubs. Mr. C. H. Danforth informed me that a specimen of *Carphophis* had swallowed a small *Diadophis*, which he had put together in a can. The species is oviparous, laying a small number of eggs (five), which are about 30 mm. long and about 7 mm. in diameter.

Dates of capture.—March 23; May 2, 4, 19; July 4, 19; November 4.

Subfamily Boiginae.

Hypapophyses present throughout the vertebral column, represented on the posterior dorsal vertebral by a more or less developed crest or tubercle projecting below the condyle.

Genus tantilla.

Maxillary teeth small, equal, twelve to fourteen, followed by a pair of feebly enlarged grooved teeth, situated below the posterior border of the eye. Mandibular teeth equal. Head small, not, or but slightly distinct from the neck. Eye small, with a round pupil. No loral shield. Body cylindrical, scales smooth, without pits, in 15 rows. Ventrals rounded. Tail moderate or short. Subcaudals in two rows. Southern North America, Central and Tropical South America.

78. Tantilla gracilis Baird and Girard. Graceful Tantilla.

Tantilla coronata, Homalocranium gracile, Tantilla hallowellii.

Description.—Rostral large, a little broader than high. Nasals two, nostril in the posterior margin of the prenasal. No loral. Anteorbital one, postorbital one. Postnasal sometimes separated from the preocular by the prefrontal. Frontal longer than broad. Temporals 1-1. Upper labials six, third and fourth entering the eye, fifth the largest.

Lower labials six, four in contact with the anterior chin shields, which are longer than the posterior. Head continuous with body, snout projecting. Eyes small. Mouth deeply cleft. Tail very slender. Dorsal scales in fifteen rows, smooth. Ventrals 112-137. Anal divided. Subcaudals 41-51 pairs.

Color.—Reddish or greenish brown above, some scales speckled with darker. Beneath salmon color, pink in life. Top of head darker brown. Labials yellowish brown.

Size.—Total length 215 mm.: tail 51 mm.

Habitat.—Texas, Arkansas, and Missouri. Missouri localities:—St. Louis, Jefferson, Ozark, and Stone Counties.

Habits.—The Tantilla leads a secretive or burrowing life. In the Ozark Plateau in Jefferson County they are common, and are found mostly under rocks on hillsides with southwestern exposure. In St. Louis County I have found only one so far. They feed on insects.

Family Elapinae.

This family contains all the so-called "proteroglyph" snakes, or snakes with a permanently erect poison fang in the anterior portion of the horizontal maxillary bone. Smaller teeth behind the fangs. These may be wanting. Head furnished with plates. Loral usually absent. Tail short, conical.

Genus Elaps.

Body elongated and cylindrical. Head small, its upper surface with the nine plates usually found in the *Natricidae*. No loral. Nasals two, with the nostril between, or mostly in the anterior one. Anteorbital one. Eyes small, pupil a vertical oval. Head little distinct from the body. Scales smooth, without pits. Subcaudals in two rows. Anal plate divided. (Hay.)

79. Elaps fulvius Linnaeus. Coral Snake. Bead Snake. Harlequin Snake.

Coluber fulvius, Vipera fulvia, Elaps tenere, Elaps tristis, Le noire et jaune.

Description.—Rostral about as high as wide, not extending between the internasals, which are rather small and about one-third the size of the prefrontals. Frontal a little longer than wide. Parietals also

longer than wide. Upper labials seven, third and fourth entering the eye. Temporals 1-1 or 1-2. Nasals two, the anterior one deeper in front than the posterior. Lower labials seven, fourth the largest. Anterior chin shields shorter than the posterior. Head a little wider than the neck, flat above. Eyes very small. Body slender and cylindrical. Dorsal scales smooth, in 15 rows. Ventrals 202-236. Anal divided. Subcaudals in 25-45 pairs.

Color.—The ground color is red, with from eleven to seventeen black rings of the body. These rings are from seven to ten scales long, and the same number of red rings, are from eight to twelve scales long. The black rings are bordered in front and behind by yellow rings, one or two scales long. Nearly all the scales in the red rings are mottled with black on the dorsal part. Three or four black and an equal number of yellow rings on the tail, but no red. Top of head in advance of the parietals is black, followed by a yellow band extending to the angle of the mouth, and a black ring from 5 to 8 scales long.

Size.—Total length 930 mm.; tail 70 mm. Another specimen is 1000 mm. long and the tail 90 mm.

Habitat.—The Coral Snake is found from Florida west to Texas and Mexico, up the Mississippi as far north as Missouri. Also in Georgia and South Carolina. So far I have never had the pleasure of capturing one of these snakes in Missouri. Some years ago I saw one in Dunklin County and Dr. C. A. Peterson noticed one near Hornersville, Dunklin Co., but in both cases the snake escaped. Dr. P. R. Hoy reports that he found it in his explorations of western Missouri in 1854. (Annual Report, Smithsonian Institution, 1865). On page 433 the doctor says "Mr. Judson caught me a few days after we had left here an *Elaps fulvius* (perhaps *E. tenere*). Is this not the most northern locality in which this beautiful southern serpent has been discovered?"

Habits.—My friend, Mr. John K. Strecker, Jr., of Waco, Texas, wrote me the following letter regarding the habits of this snake:—"One day in May I stood on the bank of a small grassy lagoon in the eastern section of McLennan Co., watching a number of water snakes that were either swimming around in the water or sunning themselves on tufts of earth and swamp grass, which were

raised above the surface of the marsh. These serpents were mostly true water snakes, such as *Natrix rhombifer, Natrix fasciata transversa,* and *Natrix erythrogaster,* also one specimen of the Lined Snake, *Tropidoclonium lineatum,* and numerous stump-tail Mocassins, *Agkistrodon piscivorus.* During the rainy season the snakes fairly swarm here, but they are more numerous in point of numbers than species. On this occasion I was trying to discover something new in the line of snakes and chancing to cast my eye on a patch of rushes on the border of the water some yards away, my gaze was at once riveted upon a most beautiful creature. Through the rushes in and out swam a sinuous body, the form of the most beautiful of serpents, the Bead, Coral or Harlequin Snake. This serpent with its bands of bright red, yellow and black contrasting with the brilliant green of the rushes and the dull color of the marsh water, made one of the most fascinating and interesting sights that I have ever gazed upon. The specimen I now beheld was probably three and a half feet long, in fact longer than any specimen I have ever collected. I was eager to capture the serpent but although I made the effort, the Elaps proved to be the quicker of the two and made for the deeper water, where it disappeared. The principal haunts of this snake are woods in the vicinity of ponds, springs and streams. Their food consists for the greater part of other snakes, such as small specimens of various water snakes and Garter snakes, but although other reptiles and batrachians are eaten the stomachs of the smaller specimens I have dissected contained remains of small ground snakes, such as the Graceful Tantilla (*Tantilla gracilis*) and the little Brown Snake, *Haldea striatula,* as well as a few small water snakes, among them the Ribbon Snake (*Thamnophis proxima*). I am inclined to believe that if these snakes were armed with movable fangs, as the Rattle Snakes, they would prove much more dangerous, as they recover themselves much more rapidly after striking than any member of the Crotalidae I am acquainted with; as it is they are com-

pelled to bite in order to inflict a wound and their mouth is so small that they can hardly be considered a very formidable reptile. When enraged they have a peculiar way of drawing back after each attempt is made to strike and instead of forming an almost perfect coil, as it is usual with some other snakes, will only half coil their body, with its beautifully colored bands, coiling and uncoiling with confusing rapidity."

The Coral Snake belongs to a family which contains some of the most poisonous snakes, such as the *Cobra di Capello* and the Australian Tiger Snake, which are provided with a venom that is more deadly in effect than that of the Pit-Vipers (Rattlesnakes, Copperheads and Cotton-mouths). Because the Harlequin Snake has comparatively short fangs many people think it a poisonous snake. but only slightly so. This is, however, a dangerously poisonous snake. Beginners in Herpetology should be very careful to learn to distinguish the Coral Snake from the red and yellow ringed *Lampropeltis.*

Ditmars in his Reptile Book says "The Coral Snake differs from Pit-vipers in seldom or never striking at the object of its anger. If cornered it will lie sullenly motionless, or throw its body into a series of irregular loops, under which the head is often hidden. If unduly annoyed the reptile behaves in a peculiar manner. It twists from side to side, lying motionless for a few seconds, then throwing itself into a different position. The movement are jerky and erratic and seemingly without purpose. Then the reptile is treacherous and dangerous. Its movements are lightning-like and quite different from those displayed by the majority of snakes. If touched lightly upon the side, the small head is swung around and the jaws grasp the offending object, which the serpent chews until the small but formidable fangs have been imbedded a number of times."

It may be well to site a few cases of the harm done by this reptile as a warning to those who see in it only a beautiful inoffensive-looking snake.

The late Dr. E. D. Cope reports the following case:—"A Swede at Oakland, Orange Co., Fla., found an *Elaps*, and because of its beautiful color he caught it and tried to put it into a bottle of alcohol. The snake bit him, but the wound was not large, and as it did not swell he did not care much about it at first. After a while he was taken very sick, went to bed, asked for a physician, and drank whisky; but it was then too late. He died the next morning, about twelve hours after the snake had bitten him. During the last hours he was unconscious, but before that he suffered most excruciating pains."

Dr. Thomas Kearney of San Antonio, Texas, relates a case as follows:—An infant child of Mr. Alexander Stringer was playing in the yard, and being attracted by the bright colors of a coral snake, grasped it near the middle. The screams of the child brought its parents to its relief, but too late; the snake had done it work. The child lingered in great agony until the following morning and died. The snake, as described to me was about 18 inches long. (Stejneger.)

Dr. Leonard Stejneger in his Poisonous Snakes of North America gives the following:—These cases were reported by Dr. J. Harff, who wrote that two men were bitten, one died in 24 hours while the other one recovered after an almost fatal prostration of thirty-six hours duration.

"The fatal case came under my observation a few minutes before death occurred under the symptoms of paralysis of the heart. The second case was brought soon enough for me to try stimulants—whiskey, hypodermic injections of ammonia and fomentations of digitalis leaves over the region of the kidneys. The man, a strong young Scotchman, recovered in three days, and felt only a feeling of tingling in his extremities for some time after. Both men kept the snakes as pets, and the last one used to put his finger in the animal's mouth very often to show how tame it was. One day he put it in a little deeper

than usual, and while trying to extricate it the teeth bit him.''

Another case reported by Dr. Stejneger is the following:—The victim was Mr. Zeno Shindler, an employee of the U. S. National Museum, and the offender a medium-sized *Elaps fulvius,* received from Mr. James Bell, of Gainesville, Fla.

''On June first, 1882, between two and three o'clock in the afternoon, preparatory to making the color sketch from the live snake which should serve for a guide in painting the plaster cast to be made from it, Mr. Shindler attempted to transfer the snake from the terrarium to a glass jar, holding it tightly by the neck. At the moment he let go, the snake's tail touched the bottom of the jar, and before he had time to remove his hand the snake fastened its fangs in his left index finger. The snake did not strike like the rattlesnake, but hit hard, closing the lower jaw upon the finger, and held on so firmly that it had to be wrenched off, by which operation one of the fangs was broken off in the wound.

''The first symptoms, which appeared immediately after the bite, according to Mr. True, consisted of violent pain at the wound. The symptoms continued without material change to 4:30 p. m. At that hour the first symptoms of drowsiness or unconsciousness made their appearance, and remained until the morning of the third day.

''At 7:30 p. m. on the day of the bite Mr. Shindler felt so ill that he deemed it prudent to call upon his physician, Dr. L. M. Taylor, of Washington, whose treatment is given in full in Mr. True's report.

''In three days after treatment the patient felt in good health again. About two months after the event, however, pain set in once more at the bitten finger, extending to the knuckles; and after a few days an ulcer made its appearance above the latter.

''Mr. Schindler tells me that every summer a few days before June 2, the day he was bitten, the wounded finger

commences to pain, mostly at night. A sore is formed and soon breaks open, and as a result the nail invariably comes off. The attack lasts for about two weeks.

"Two years ago, however, and ten years after the accident, the recurrence was prevented by a remedy commonly used in Brazil against snake bite, and brought to Mr. Shindler from that country by his friend, Dr. A. de Bausset. The remedy consists of the leaves and stem of a vine (*Micania guacho*) an infusion of which was taken internally immediately before the expected recurrence of the symptoms, with the result that, although the pains arrived on time, no eruption took place."

The Coral Snake is of burrowing habits. It is sometimes found hiding under the bark of decaying logs, and is often brought up in ploughing. After heavy showers and at night it issues forth in search of food, which consists of snakes and lizards. The Bead Snake is oviparous. Its eggs are very elongate and are deposited in decaying bark or damp soil. The snake lays about seven eggs at the end of June, which hatch at or about the 27th of September.

Superfamily Crotaloideae.

Maxillary bone vertical and movable. Ectopterygoid (transpalatine) present, extending to mandible; supra temporal present, attached scale like to the skull and suspending quadrate. Maxillary much abbreviated, erectile perpendicularly to ectopterygoid, supporting a pair of large poison fangs, without external groove. Mandible without coronoid bone. Hypapophyses developed throughout the vertebral column.

Family Crotalidae.

A deep "pit" between the nostril and the eye. Head triangular, broad behind, flat and distinctly separated from the body by a small neck. Maxillary bone much shortened, moving freely on the lachrymal and supporting a single functional, enlarged, tubular tooth, or poison fang, which is capable of erection and concealment under a fold of lining of the mouth. Poison glands at the side of the head. Pupil oblong, vertical. Scales keeled. Anal entire. Body thick and short. Tail short. All are venomous.

"Pit Vipers," a name meant to include the Rattlesnakes, Moccasins, and Copperheads, is a most excellent

one, for not only does it indicate the relationship of these snakes to the true vipers, but it also contains a reference to the remarkable character which at once distinguishes them both from the vipers and all other snakes as well. The name refers to a deep pit or hole found in the Rattlesnakes and their nearest relations on the side of the face between the nostril and the eye. This cavity sinks deep into the maxillary bone and represents a "blind" sac lined with epidermis and is not connected with any of the other cavities or organs in the head by any inside opening or canal. There is nothing similar to be found in any known reptiles outside of this family, if we except the labial pits in the pythons and boas, nor is there any in any other class of animals.

"In the meantime naturalists have become compelled to assume the existence of a 'sixth sense' in various animals, for which they had discovered special sense organs, such as, the lateral line in fishes.

"It was quite natural, then, that Prof. Leydig should come to the conclusion that the pit of the Crotalidae is the organ of a sixth sense, when upon a microscopic examination of the pit's lining he found it supplied with a thick nerve, ending in a way the only analogue of which is found in the retina of the eye or the labyrinth of the ear.

"The external layer of the lining of the pit Leydig found to be a continuation of the outer skin, which, however, upon entering the cavity becomes thin and considerably modified. The granular tubercles gradually disappear toward the bottom, and the surface is found to be composed of large angular epidermis plates containing nuclei. Underneath this he found a layer of connective tissue, in which the fine ramifications of the thick nerve supplying the pit are lost in a granular substance which under high power reveals itself as containing numerous, true, rounded, but pale nuclei. The granular substance he found arranged around the nuclei in such a way as to form groups or islands of various forms and sizes separated by light narrow spaces. These structures can only

be regarded as terminal ganglions, and it does not seem doubtful that we have here to do with a true sense organ.

"Wherein this 'sixth sense' consists we do not know, nor do we know of anything in the habits of these snakes which would indicate its nature, or to what use the animal puts the organ. Future research may reveal it, though perhaps man will never fully comprehend the nature of a sense which he himself does not possess." (Stejneger.)

Key to the Genera of Crotalidae of Missouri.

Tail not provided with a rattle.	*Agkistrodon.*
Tail provided with a rattle.	
Top of head with plates.	*Sistrurus.*
Top of head with scales.	*Crotalus.*

Genus AGKISTRODON.

Nine cephalic plates. A pit between the eye and nostril. A pair of erectable poison fangs. Scales keeled, in 21-27 rows. Anal entire. No rattle.

Key to the Species in Missouri.

No loral plate; a pair of post-parietals; upper labials entering the orbit. Usually 25 scale rows.	*piscivorus.*
A loral plate; no post-parietals; orbit separated from upper labials by scales. Usually 23 scale rows.	*contortrix.*

80. Agkistrodon piscivorus LaCépède. Water Moccasin. Cotton Mouth.

Trigonocephalus piscivorus, Toxicophis piscivorus, Scytale piscivorus, Cenchris piscivorus, Toxicophis pugnax, Acontias leucostoma, Natrix piscivorus, Coluber aquaticus, Le Piscivore, Vipera aquatica.

Description.—Rostral large, vertical, truncate above. Internasals triangular, frontal large, longer than wide, hexagonal. Nasals two with the nostril between them. A pair of small triangular plates behind the parietals, which are pentagonal. Pre-oculars two or three, the upper much the largest. Post-oculars two or three, with one or two sub-oculars. Upper labials eight, the third the largest and entering the eye. Ten lower labials. Anterior chin shields much larger than the posterior. Head broad, flat on top, snout rounded. Canthus rostralis sharp. Neck contracted. Body very stout. Tail short, compressed, one-seventh to one-sixth of total length. Dorsal scales in 25

rows, strongly keeled. Ventrals 130-147. Anal entire. Subcaudals 39-48, more or less of which are undivided. The end of the tail with a sharp nail.

Color.—Color above brown to blackish, with about eleven transverse black bands alternating with as many brown bands, the latter widening on the back and with a dusky center, the black bands widening at the sides and often with a brown area in the expanded lateral portion. Sometimes uniform blackish brown, with numerous black blotches beneath, black posteriorly. Head uniform brown or black above, with a wide black band, edged above with brown and below with yellow, extending from the eye over the angle of the mouth and terminating on the neck. Tail uniform black, or with a few pale spots beneath, posteriorly, sometimes banded. (Garman.)

In the young of the Cotton Mouth the colors are brighter and the pattern more distinct.

Size.—A. E. Brown gives the size of a very large specimen as 1550 mm. long and 250 mm. in circumference.

Habitat.—From Southwest Virginia, south throughout Florida, to Texas and the Rio Grande. It ascends the Mississippi to southeast Missouri, and the Ohio to the Wabash River. Missouri localities:—Butler, Stoddard, and Dunklin Counties.

The late Mr. Specking, at one time teacher in a country school at Delta, Cape Girardeau Co., assured me that the Cotton Mouth was plentiful in the cypress swamps of that neighborhood. Mr. W. S. Savage of Monteer, Shannon Co., enumerates the Cotton Mouth from Shannon County.

Habits.—The name "Water Moccasin," properly belonging to this species, is often applied to the common Water Snake in parts of Missouri where the "Water Moccasin" does not occur. This mistake can easily be made as the two species resemble each other somewhat, especially old specimens. In the "Sunken Lands" of Missouri the Water Moccasin is abundant along the water courses. It may be seen on hot days basking in the sun on water plants. When disturbed it opens its mouth, which is mostly white on the inside. This has given rise to the popular name "Cotton Mouth." It vibrates its

tail like a rattlesnake, but in a slower rhythm, and retreats to the water for safety. When upon a higher log, they tumble headlong into the water when alarmed. The Cotton Mouth lives on fish, frogs, birds, smaller mammals, and other snakes, but it is said not to devour its own kind. Dogs and cattle bitten by this snake become very sick, but recover in a very short time. Notwithstanding the fact that the poison of the Moccasin has been found proportionately less virulent than that of the Rattle Snake and Copper Head, the fear it inspires is well founded for it is much larger and heavier snake than the Copperhead. The snake is ovoviviparous. It brings forth from two to seven young at a time, which show the color pattern to perfection. A Cotton Mouth, which I caught July 3rd, near Bertig, Dunklin Co., Mo., gave birth to six young ones on September 18th.

Dates of capture.—April 24; July 3; September 5.

81. Agkistrodon contortrix Linnaeus. Copperhead. Moccasin.

Boa contortrix, Ancistrodon mokason, Scytale contortrix, Cenchris mokeson, Scytalus cupreus, Cenchris marmorata, Cenchris contortrix, Trigonocephalus cenchris, Trigonocephalus contortrix, Ancistrodon contortrix, Acontias atrofuscus, Trigonocephalus atrofuscus, Trigonocephalus historionicus, Ancistrodon atrofuscus.

Description.—Rostral broad and high. Two internasals. Generally three prefrontals, the median small. Frontal pentagonal, as wide as long. Parietals about the size of the superciliaries, showing a tendency to break up into small shields. Nasal divided with nostril between. Loral present, separating the posterior nasal from the superior ante-orbital. Ante-orbitals three, the inferior one very small. Post-orbitals 3-4. Eye entirely separated from the labials by the suboculars. Upper labials eight (seven), the second twice as high as long, bounding the pit in front and reaching the loral. Lower labials nine or ten. Head wide, flat, triangular with the sides in front of the eyes vertical, with a sharp canthus rostralis. Body less stout than in *A. piscivorus*. Tail short, tapering, about one-eighth the total length and ending with a curved horn or nail. Dorsal rows 23, strongly keeled. Ventrals 145-155. Anal entire. Subcaudals 31 to 52, all entire except the last 8 to 18 pairs.

Color.—Color above of a peculiar yellowish pink (in life), often pale drab with a series of inverted Y-shaped brown marks on each side. Beneath yellowish with a series of black blotches on each side. Top of head often bright copper, whence the name "Copperhead." On the sides of the head a white, yellowish band, which posteriorly rounds the angle of the mouth and extends forward on the lower labials. Each parietal with a brown spot. When born, the young snakes have vivid sulphur-yellow tails.

Size.—Total length 1000 mm.; tail 130 mm. Another specimen, total length 990 mm.; tail 110 mm.

Habitat.—From Massachusetts south to Florida, west to Texas, north through Oklahoma and Kansas. Missouri localities:—St. Louis, Jefferson, Shannon, Ripley, Howell, Ozark, Stone, Johnson, Miller, Randolph, Warren, Montgomery, and Pike Counties. In Illinois St. Clair County.

Habits.—The Copperhead is of rather common occurrence. It is mostly found on shady, rocky hill-sides, and not far from water. It feeds on birds, small rodents, frogs, and snakes, but becomes itself in turn a victim of some other snakes, as the Blue Racer (see *Bascanion constrictor*) and King Snakes. In the spring of the year I caught two middle sized Copperheads, which I kept alive for observation. I supplied them regularly with food and water, but they refused to eat. They held out a whole year, finally dying of starvation.

"When disturbed in its native haunts this snake will generally make an effort to glide quietly away if escape is open. If caught at close quarters, and flight be impossible, it defends itself vigorously, throwing the body into a series of irregular loops and striking in the direction of the enemy. At such times a rapid, vibratory movement is communicated to the tail, which produces a distinct, buzzing sound, if the serpent be among dry leaves. Throughout all these manoeuvres the snake is usually backing away in an endeavor to make a dash for safety, by gliding into a nearby friendly thicket or among the rocks. Like the moccasin, if held down with a stick in an endeavor to effect its capture, it fights furiously, thrash-

ing the body from side to side in an effort to twist itself free and often in its excitement unconsciously throwing a portion of its body against the widely distended jaws with their sharp fangs, which immediately close, inflicting a wound upon itself, which is never mortal, as the venomous snakes are immune to their own and to each other's poison." (Ditmars.)

The venom of the Copperhead is to my experience more virulent than that of the Cotton Mouth and the smaller Rattle Snakes. This snake is a much more vicious animal than the Rattlesnake, not only because it strikes without giving any warning, but also because it is of a much more aggressive nature and quick in its movements. Dr. R. E. Kunze (American Naturalist, **17**:1229. 1883), thinks that the Copperhead does not strike from a regular coil, like the Rattlesnake, but that its effective blow is delivered when the middle of the body is thrown into long, almost rectangular curves, and the head held only slightly elevated above the ground. The Copperhead is ovoviviparous, producing from four to nine young ones. July 27, 1895, when dissecting one of these snakes I found thirteen embryos, each about 3" (76 mm.) long.

Dates of capture.—April 4; May 6; June 23; July 27; September 1, 30.

Genus SISTRURUS.

A pair of large erectable, perforated poison fangs in front of upper jaw; no other maxillary teeth. Loral pit and rattle present. Top of head covered with large plates, scales keeled, with pits in 21 to 25 rows. Anal and subcaudals not divided. Size small to medium.

Key to the Species in Missouri.

Postnasal in contact with preocular. The light line to angle of mouth begins at nostril. *catenatus.*

Postnasal separated from preocular by loral. Light line to angle of mouth begins at the eye. *miliarius.*

82. SISTRURUS CATENATUS Rafinesque. Prairie Rattlesnake. Massasauga.

Crotalinus catenatus, Crotalus tergeminus, Crotalus massasaugus, Crotalophorus tergeminus, Crotalophorus catenatus catenatus, Crotalophorus massasaugus, Crotalophorus kirtlandi, Caudisona tergemina, Sistrurus catenatus catenatus.

Description.—Rostral high, narrow, broader near the lower edge. Canthus rostralis pronounced. Two internasals, triangular, anterior margin convex, the posterior concave, the outer margin raised. Two prefrontals, the outer margin also raised. Frontal pentagonal, often broken in several shields (three). Superciliaries large. Parietals broad, rounded posteriorly. Nasal two, with nostril between, which is very small. Loral irregular in shape. Preoculars 2-3, long, the upper reaching nearest to the internasals. About four postorbitals and as many suborbitals. Upper labials 10-13. Lower labials 12-15. Head moderately wide, neck contracted. Body short and stout. Tail about one-ninth of total length. Rattle small. Dorsal rows of scales 25, keeled except the two outer rows on each side, which are smooth. Ventrals 136-153. Anal entire. Subcaudals 21 to 31, entire, with only about six posterior plates divided.

Color.—Above brown, with about 30-36 deep chestnut-brown dorsal blotches, blackish externally and with yellowish-white margins. Three lateral series of brown blotches, which alternate with the dorsal ones The upper series is generally much paler. A narrower band of yellowish-white from the post-nasal below the orbit to the angle of the mouth. There is also a grayish band from eye to eye over the anterior half of the superciliaries and frontal; a dark brown band on the cheeks from the eye to the neck, followed above and on the occiput by a light grayish band and between these is a long brown blotch, reaching also to the neck. Beneath the color is blackish brown and yellowish. The end of the tail in newly born is whitish yellow. Sometimes the snakes are of a uniform black all over. (*S. kirtlandii.*)

Size.—Total length 777 mm.; rattle 39 mm. Newly born are about 135 mm. long.

Habitat.—From Michigan to Wisconsin, south to Nebraska, Kansas, Missouri, Illinois, Indiana, and Ohio. Missouri localities:—St. Charles, Lewis, Randolph, and Warren Counties. In Illinois, West Prairie near Mitchell, Madison County.

Habits.—So far I have only found the Massasauga at West Prairie, Madison Co., Ill., and at Dardenne Prairie, St. Charles Co., Mo. Both of these places are inundated

annually by high water from the Mississippi River. May 15, 1890, my son and I went over to West Prairie. The night before the water from Cahokia Creek had overflowed the whole prairie from 3 to 6 inches. On every small elevation or heap of ground we found several Massasaugas, utterly exhausted. Within two hours we had collected fifty-nine, mostly half grown, but some very large specimens—over 730 mm. long. We searched for the sixtieth but did not find it. We packed the fifty-nine in two medium sized minnow buckets and found them all alive on reaching home some three hours later. From August 22 to September 2 their young were born, from seven to nine by each female. They were about 135 mm. long. All had a yellow tip to the tail provided with a button. They were ejected in a thin yellowish covering or egg shell, which broke immediately. The first thing the young ones did was to open their mouths as if trying their fangs. At present a large part of that prairie has been drained and cultivated, and the Massasaugas have disappeared. Other animals bitten by this snake suffer much and have troublesome swellings. On the average this species is considerably smaller than the Timber Rattlesnake, and hence less to be feared. The fangs are proportionally smaller and the amount of poison injected in a wound consequently less. They should not, however, be tampered with. Goode includes this snake among those which allow the young a place of safety in the stomachs of the females.

Dates of capture.—April 15; May 20, 28.

83. SISTRURUS MILIARIUS Linnaeus. Ground Rattlesnake. Pigmy Rattlesnake.

Crotalophorus miliarius, Caudisona miliaria, Crotalus miliarius, Le Millet, Vipera caudisona americana minor.

Description.—Rostral deeper than broad, perpendicular, truncate at top. Nasals two, higher than long. Frontal as long as its distance from the end of the snout, shorter than the parietals. Loral present,

separating the post-nasal from the preocular. Eyes separated from the upper labials by one or two series of plates. Temporal scales keeled. Nine to eleven upper labials. Smaller and more slender than *S. catenatus*. Rattle very small. Snout with a sharp canthus. Dorsal scales in 21 or 23 rows, all keeled, the two outer rows slightly. Ventrals 127-140. Anal entire. Subcaudals 25 to 36, on the terminal fifth of the tail they are divided.

Color.—Gray, yellowish to dark brown, the vertebral line often orange. One or two dorsal series of large, dark black-edged spots or a series of narrow cross bars and one or two lateral series of smaller spots, two undulating dark stripes from between the eyes to the occiput, the space between them usually orange. A dark temporal streak with a light streak below, extends from below the center of the eye to the angle of the mouth, whitish yellowish beneath, speckled and spotted with dark brown. A light stripe over the superciliaries and frontal from eye to eye.

Size.—Total length 550 mm.; tail between one-seventh and one-eighth of that length. Another specimen total length 520 mm.; tail 70 mm.

Habitat.—From South Carolina south to Georgia and Florida, west through Alabama, Louisiana and Texas, up the Mississippi Valley through Mississippi, Arkansas and southern Missouri. Missouri localities:—Stone, Oregon, and Shannon Counties.

Habits.—I have never found one of these Pigmy Rattlesnakes myself. One specimen in my collection came from Mitch, Oregon County, sent to me by my friend, Mr. Robert Lotze, who had a farm in that neighborhood. He found it in clearing away the debris in a shanty on the farm. Those from Stone County were collected by Mr. Lee Earll, guide at Marble Cave. From one he had taken seven embryos, August 19th, each about 165 mm. long.

Mr. R. L. Ditmars in his Reptile Book gives the following:—"Owing to its diminutive size, this species is the least formidable of the North American Crotaline Snakes. By many, however, it has been argued that the Coral Snake, (*Elaps fulvius*) should be placed last on the list as regards the virulency of the bites of venomous serpents inhabiting the United States. The writer cannot agree with this contention. Although the fangs of the Coral Snake may be smaller than the weapons of the

Pigmy Rattlesnake, the former serpent is provided with a more powerful poison which makes up for the deficiency in size of the venom conducting teeth and possibly a smaller amount of poison discharged from them.''

So small is the rattle of this species that its whirring can only be heard a few feet away. The Pigmy Rattler is fond of frogs but will also eat small rodents and very young birds. It is ovoviviparous.

Genus CROTALUS.

A pair of large, erectable, perforated poison fangs in front of the upper jaw. Loral pit and rattle present. Top of head covered with small scales. Dorsal scales keeled (outer sometimes smooth), with pits, in 23-31 rows. Anals and subcaudals not divided.

84. CROTALUS HORRIDUS Linnaeus. Timber Rattlesnake. Banded Rattlesnake. Northern Rattlesnake.

Crotalus durissus, Crotalus horridus var. atricaudatus, Crotalus atricaudatus, Crotalinus cyanurus, Caudisona horrida, Uropsophus durissus, Urocrotalon durissus, Caudisona durissus, Crotalophorus horridus, Vipera caudisona americana.

Description.—Rostral higher than broad, prefrontals two. Two nasals, the anterior larger, nostril in the posterior one. Two rows of small plates behind the nasals. Two anteorbitals, the upper the larger, the lower smaller, forming the upper margin of the pit. Four to eight scales between the supraoculars, two to four between the suborbitals and labials. Upper labials fifteen, lower eighteen. A pair of large elongated chin shields. Head broad, triangular, flattened above. Snout blunt. Eyes small. Superciliaries large, projecting over the eye. Pupil elliptical, vertical. Neck contracted abruptly behind the head. Tail short, compressed, not tapering. Scales in 23-25 rows, strongly keeled, excepting the outer row on each side, which is either smooth or obsoletely keeled. Ventrals 165-178. Anal entire. Subcaudals 18-25, undivided.

Color.—Color above brownish yellow to almost black, posteriorly, with transverse zigzag bands of chestnut brown, edged with black and bordered outside the black with yellow, anteriorly with three series of brown spots bordered in the same manner. Beneath yellowish, more or less blotched and speckled with black at the sides. Head uniform brown above, with a wide brown band extending from the eye obliquely downward and backward over the angle of the mouth. Tail black in adults, banded in young. (Garman.)

Size.—Total length 1080 mm.; tail 114 mm., with ten rattles. Ditmars reports the largest Timber Rattler he ever examined came from Missouri. He gives the following measurements. Total length just six feet (1829 mm.); 2½ inches (63 mm.) in diameter at the thickest part of the body. The head was proportionately very small, showing a total width of 1⅞ inches (47 mm.). The rattle had 14 uniform segments.

Habitat.—New England to northern Florida, west to eastern Kansas, Oklahoma and Texas. Missouri localities:—Once very common throughout the state but being rapidly exterminated. In Illinois, St. Clair County (Falling Springs).

Habits.—The Timber Rattler is mostly found on bluffs and hill-sides exposed during the greater part of the day to the sun. They seem to prefer large ledges composed of flat rocks.

Ditmars in his Reptile Book gives the following account:—"About such rugged situations large numbers of rattlesnakes gather in the fall, preparatory for the hibernating season. They appear to find the same places, year after year, making their way from the adjoining timber and lesser ledges as if led by some strange, instinctive power. On the main ledge, they coil sociably in great clusters to enjoy the sun of "Indian summer"—but only for a limited number of days, when they retire into the deep fissures for the winter's sleep. Such places are the so-called "snake dens". During the summer they are mostly found in the woods and fields nearby, but it seems they do not wander very far from their winter quarters.

"In a wild state, the Banded Rattlesnake prefers flight to combat and, though rattling harshly when disturbed, will generally glide away, sounding its warning note as it goes. If cornered it will fight bravely, assuming a loose irregular coil, and striking with such dexterity that the eye can scarcely follow the movement. It strikes generally a third, sometimes half its length, but never springs bodily as alleged by the writers of sensational snake stories. Nor is it necessary for the snake to be coiled to deal a blow. While retreating towards shelter it will

often turn and from a crawling position draw back the head by contracting the neck into an S-shaped loop, and strike readily.''

The Timber Rattlesnake feeds on warm blooded animals, such as small rabbits, squirrels, rats, mice, and birds. Into the cage containing a large specimen I introduced a young cat, which the snake struck almost immediately. In about fifteen minutes the cat was dead, but was not touched by the snake for a whole day. In this time putrification had set in, but on the morning of the second day the cat had disappeared. The Timber Rattler is ovoviviparous, bearing from nine to twelve young, which are about 300 mm. long. The young are provided with the button, representing the future rattle.

Dates of capture.—April 4, 26; May 18; October 1, 16; November 20.

The Rattle.

''A persistent and popular idea is to the effect that the age of a snake may be told by counting the rings or segments of the rattle. With the majority of specimens such calculation is impossible. According to the popular and incorrect opinion, the snake acquires a new joint or ring of the rattle every year, and if one desires to ascertain the age of the reptile it is simply necessary to count the number of rings composing the rattle, and, by allowing a year for each ring, the age of the serpent is known, but this theory is wholly incorrect and very misleading.

''In the first place, the rattlesnake acquires from two to three rings of the rattle each year. The rattle seldom attains a length of more than ten to thirteen rings as when that number has been acquired the vibration at the tip, when the organ is used, is so pronounced that additional segments are soon worn, broken and lost.

''When the young Rattlesnake is born, it is provided with a soft button on the tip of the tail. Within a few

days after birth the young Rattlesnake sheds its skin and commences feeding, taking small mice, or other young rodents. It grows rapidly and in about two months sheds the second skin when the first ring or segment of the rattle is uncovered. This has been steadily developing under the old epidermis and at such times its presence was apparent in the swollen appearance at the base of the original button. Immediately after the shedding of the skin, this ring is black and soft. It loosely encases the base of the button, and, after a few days, when the segment has become thoroughly dry and the tail is shaken, a faint, buzzing sound is produced—this is caused by the loosely attached button rasping against the dry segment to which it is fastened. Now that the button has become detached from the base of the tail, it becomes a dull straw color—the general hue of the rattle. At this time the snake has a rattle in miniature. Every succeeding segment is produced in exactly this fashion.

"It can thus be appreciated that if the rattle of a snake possesses the original button of birth, we may estimate the age of the reptile by allowing the button and first ring for about the first nine months—this including the period of the first hibernation, and counting each three additional rings as a year. The reptile usually sheds its skin three times during the warm season, in the spring, during mid-summer and in the fall. If the button has been lost through wear or accident and the rattle has a distinctly tapering outline toward its tip, the number of lost segments may be estimated, but if all the segments are of uniform size, it will be understood that the rings of youth have been lost and possibly many others. With such a specimen there is no way of ascertaining the age." (Ditmars.)

The Poisoning Apparatus.

Dr. S. Weir Mitchell gives an account of the Rattlesnake, its bite and poison in the third chapter of "Research upon the Venom of the Rattlesnake," published

in 1860 by the Smithsonian Institution in Contributions to Knowledge, entitled "The Physiological Mechanism of the Bite of the Crotalus." This same paper was given in a more popular form in the Century Magazine, Vol. 38, August 1889.

"When the Rattlesnake is in repose and unmolested, it sometimes lies at length, sometimes coiled, or wrapped fold on fold in the loops formed by other snakes which may happen to be in the same box. So soon, however, as cause is seen for alarm, the snake extricates itself, if among others, and at once throws its body into the coil so familiar to anyone who has seen serpents, whether venomous or not. Sometimes on the edge, more often in the center of the coil, the tail projects far enough to admit of its vibrating freely and with singular swiftness.

"The head is raised a little above the rest of the body, but not, usually, more than three or four inches, even in large snakes. The neck and upper end of the trunk are not thrown into complete circles, but lie in two or three abrupt curves across the mass of the coiled body. While thus at bay, in an attitude of singular grace, the long black tongue is frequently protruded. Just before the blow the snake makes a hissing sound, which is caused by the act of expiration, and is due to the passage of air through the narrow glottis. The snake is now ready to strike.

"It has occurred to me that in telling my story it might be well to show in a popular shape its results. To make it clearer, I must first explain the mechanism which enables the serpent to use its poison.

"We have in America as venomous serpents the Rattlesnake, the Water Moccasin, the Copperhead, and the beautiful Coral Snake. India is pre-eminently the home of the poisonous snakes. The Cobra is most abundant, but the *Ophiophagus elaps* is the most dreaded, and attains at times the length of fourteen feet. Unlike the Cobra and the Crotalus, this serpent is viciously aggressive, and will pursue a man with ability.

"Among the Vipers the *Daboya* is entitled to rank as

a poisoner close to the Cobra, and the Crotalidae are represented by a number of snakes which are somewhat less effective slayers than the Cobra. All of the great family of Vipers have substantially the same mechanical arrangement for injecting their venom. When not in action the two hollow teeth known as fangs lie pointing backwards, wrapped in a loose cloak-like cover, a fold of the soft skin of the interior of the upper jaw. At the base of each of these fang teeth is an opening connected with a tube running backwards under the eye to an almond-shaped gland which forms the poison. This gland holds in its cavity a supply for use. Over the gland runs a strong muscle, which is ordinarily employed to close the mouth by lifting the lower jaw, to which it is made fast. A little circular muscle around a part of the duct keeps it shut and prevents waste of venom.

"Previously we have left the snake thrown into its coil, carrying its head ready for an attack. The snake does not pursue but waits. Little animals he scorns unless he is hungry, so that the mouse or the toad he leaves for days unnoticed in his cage. Larger or noisy creatures alarm him. Then his head and neck are thrown far back, and with an abrupt swiftness the jaws widely separated, he strikes once and is back on guard again, vigilant and brave. The blow is a stab, and is given by throwing the head forward while the half-coils below it are straightened out to lengthen the neck and give power to the motions which drive the fangs into the opponent's flesh; as they enter, the temporal muscle closes the lower jaw on the part struck, and thus forces the sharp fang deeper in. It is a thrust aided by a bite. At this moment the poison duct is opened by the relaxation of the muscle which surrounds it, and the same muscle which shuts the jaw squeezes the gland, and drives its venom through the duct and the hollow fang into the bitten part.

"In so complicated a series of acts there is often failure. The tooth strikes on tough skin and doubles back

or fails to enter, or the serpent misjudges distance and falls short and may squirt the venom in the air, doing no harm.

"A snake will turn and strike from any posture, but the coil is the attitude always assumed when possible. The coil acts as an anchor and enables the animal to shake its fangs loose from the wound. A snake can rarely strike beyond half its length. If both fangs enter, the hurt is doubly dangerous, because the dose of venom is doubled. At times a fang is left in the flesh, but this does not trouble the serpent's power as a poisoner, since numberless teeth lie ready to become firmly fixed in its place. The nervous mechanism which controls the act of striking seems to be in the spinal cord. Snake charmers generally have the fangs of their snakes pulled, or they are daily teased into biting a bundle of rags tied to a stick. They are then too tired to be dangerous. After three or four fruitless acts of instinctive use of their venom they give up, and seem to become indifferent to approaches, and even to rough handling.

"When a man or an animal is bitten by a poisonous snake, death may take place in a few minutes. It has followed in man within a minute, but unless the dose given be enormous, or by chance enters a vein, this is very unlikely. Usually the animal struck gives a cry, and very soon becomes dull and languid. The heart, at first enfeebled, soon recovers, the respirations become slower and weaker and more weak, paralysis seizes the hind legs, the chest becomes motionless, and at last death follows, usually without convulsions. If the animal should chance to survive over a half hour, the part bitten swells, darkens, and within a few hours the whole limb may be soaked to the bone with blood, which has gotten out of the vessels and remained fluid in place of clotting. What is at first local by and by becomes general, and soon the blood everywhere ceases to have power to coagulate. Then leakages of the vital fluid occur from the gums or into the walls of the heart, the lungs, brain, and intestines, and give rise

to a puzzling variety of symptoms, according to the nature of the organ thus disordered. These phenomena make the second stage of poisoning, and with them there is, in finally fatal cases, a continuous and increasing damage to the nerve centers that keep us alive by energizing the muscles which move the chest walls and so give rise to the filling and emptying of the lungs. The animal bitten perishes by slow suffocation.

"The deadly apothecary does not succumb to its own drug, but other snakes readily succumb.

"The popular notion of the immunity of some animals has little foundation. Cold-blooded creatures die slowly from snake bite, and the hog escapes only because it does not get seriously bitten. His bristles, tough skin, and clever mode of attack save him. Little pigs are often bitten and die like other creatures.

"The size of the serpent, the time which has elapsed since it has bitten, determines also the extent of damage it can do. The nervous mechanism which controls the act of striking seems to be in the spinal cord, for if we cut a snake's head and then pinch the tail, the stump of the neck returns and with some accuracy hits the hand of the experimenter, if he has the nerve to hold on."

Dr. L. Stejneger in his "Poisonous Snakes of North America" (1895) gives an adventure of Mr. George Catlin on the Rio Trombute, one of the tributaries of the Amazon. The story as told by Mr. Catlin's companion is to the effect that Mr. Catlin having shot at the head of a huge Rattlesnake had apparently missed it, as the snake was seen to strike and hit him in the breast, where it left a bloody spot on the shirt. The dress was torn open and one of his half-breed companions prepared to suck the poison out of the supposed wound; but looking a moment for the puncture, he got up, and with a smile of exultation he said, "There's no harm; you'll find the snake without a head." In the weeds nearby the snake was found, closely coiled up, where it had fallen, with its headless trunk erect and ready for another spring, the head having been

shot off. If we make some allowance for the necessarily high coloring of the narrative and the exaggeration almost inseparable from an account of an occurrence so strange and exciting, there seems to be no good reason to doubt that it took place in the main as related."

The Charming or Fascinating Power of Poisonous Snakes.

In his work "The Poisonous Snakes of North America" Dr. Stejneger gives the following:

"The popular belief in the power of the poisonous snake to 'charm' its victims into a state of helplessness is by no means exterminated. In spite of all that has been argued and explained against it there are people still who profess to have ocular proof of this power. Time and again it has been related by trustworthy observers how birds or small mammals have been seen to approach the coiled snake, drawn toward it as by a magic spell they were unable to withstand; how, under the influence of an excitement which made them forgetful to everything around them, apparently dreading the terrible fate awaiting them yet unable to avoid it, they finally ventured too near, only to be hit by the lightning stroke of the hitherto almost motionless snake, whose only sign of life consisted in the following of the victim's mad efforts with the staring eyes and the incessant darting out and in of the rapid tongue. Many of these blood-curdling tales are unfortunately embellished with such absurd details, evidently the children of an inflamed imagination, as to throw discredit on the whole story. It is not uncommon to hear it stated that the eyes of the snake were emitting fire, and that the unfortunate victim finally darted directly into the widely expanded mouth of the expectant reptile.

"In spite of these extravaganzas, however, there is evidently enough truth in the numberless observations of this nature to keep the scientists busy trying to evolve

a theory by which to explain so much of the stories as appeared worthy of being admitted as facts."

In all my experience of hunting and collecting reptiles for over thirty years, I have never witnessed any of these so-called "charming exhibitions."

The Treatment of Snake Bites.

"Evidently the first thing to ascertain is whether the case is really that of a bite by a poisonous snake. If consisting of one or two isolated punctures, the wound is almost certain to be caused by a poisonous bite, and the distance between the two punctures will usually give a clew to the size of the snake and consequently to the presumable degree of poisoning. If the snake or its head are secured, the identification may be comparatively easy, as all our poisonous snakes, with the exception of the Coral Snake, are readily recognized by the pit between the eye and the nostril.

"In very severe and acute cases, in which the venom has been injected directly into the circulation, no matter by what kind of snake, the chances for recovery are very slight indeed. The only chance in such cases seems to be to stimulate the nervous centers as speedily as possible, the best known means to this end being injection of large doses of strychnine, if necessary, intravenously, until tetanic effects are obtained and the patient roused from the coma which has probably seized him. This result obtained, other systematic or local remedies, as the case may require, can then be applied.

"A similar treatment also seems advisable in such cases of slow poisoning in which the patient has already reached a stage of collapse, or coma, before assistance can be rendered, provided not more than twenty-four hours have elapsed since the bite was inflicted, in which case injections of strychnine seem inapplicable.

"If in case of slow poisoning help can be administered very soon after the infliction of the wound and the venom

has been localized by ligatures and minimized by incision of the wound, sucking, or, better, cupping of the blood, the treatment next to be applied depends upon whether the offending snake is a Pit Viper or a Coral Snake, for if it was a rattlesnake, a copperhead or a water moccasin, attention should at once be directed to the local lesion, unless the state of the patient imperatively demands an immediate stimulant, in which case *small* doses of alcohol may be useful. Apparently the best treatment of the local lesion is a 1 to 100 solution of chromic acid injected into the incised wound, the punctures of the fangs, and into the surrounding swelling, as quickly as circumstances will allow, since the success of this treatment depends upon the chemical reaching and destroying the venom before it is absorbed into the circulation. Kneading of the tissues surrounding the wound in order to bring the venom and chemical in close contact may be useful. If chromic acid is not at hand, chloride of gold, permanganate of potassium, etc., may be substituted.

"There does not seem to be any necessity for amputation in a case where hypodermic injection of any of these chemicals can be applied. It can only be recommended in such extreme cases in which these remedies are not to be had, and the danger is great. But even in this case the amputation must follow quickly or not at all.

"The local lesion having been attended to, the general systematic treatment may commence, as by this time the venom has probably already entered the circulation, it being necessary occasionally to loosen the ligatures for a moment to prevent mortification. Alcohol in small doses and washing out of the stomach may now be in order, as well as the administration of suborific and diuretic remedies, preferably extract of jaborandi. Hypodermic injections of 15 to 20 minims of liqu. strychinae repeated every twenty minutes until slight tetanic spasms appear, seem to be warranted. Constant watching for relapses, and attention to the local lesion will do the rest.

"The action of the venom of the Elapid snakes (Coral snakes) being so much more rapid and the local changes so insignificant as not to cause any great alarm, the chances are that when the patient asks for help and treatment the venom has already entered the circulation, and that attempt to destroy any appreciable quantity of the poison in the wound would be futile. However, whenever possible this should not be neglected. The usual first treatment would nevertheless be general, viz., the administration of stimulants, suborifics and diuretics as instanced above, since the danger from a quick paralysis of the nerve centers is so much greater in these cases.

"It may be well to emphasize here, that in the case of children the amount of antidotal remedy to be administered must not be judged by the age of the child, but by the amount of venom to be counteracted, as well as by the character of the snake, and it is worth remembering in this connection—beside the different action of the crotalid and the elapid snakes—that the degree of danger chiefly depends upon the size of the snake; that of our pit vipers the rattlesnake is the most dangerous, the copperhead less so, and the water moccasin the least so, although in itself not to be trifled with.

"As for the preliminary treatment before medical assistance can be obtained or rational remedies applied, but little can be added to the old methods employed. The first thing to be done is to tie a strong ligature or two, a string or a handkerchief, between the wound and the heart, whenever practicable; next, cutting deeply into the punctures so as to make the blood flow freely; sucking out of the blood from the wound, a procedure perfectly harmless, unless the person doing it has an open wound in the mouth; next, a careful loosening of the ligature so as to admit a small quantity of fresh blood to the ligated member in order to prevent mortification; next, administration of a stimulant; if at hand, small doses of an alcoholic liquor being given internally at frequent intervals; if

alcohol is not at hand, and a stimulant appears imperative, a small dose of ammonia might be given, but only very shortly after the bite, not on a later stage when it will certainly do harm, at least in cases of poisoning by rattlesnake, copperhead, or water moccasin; if the patient has to wait for the arrival of a doctor, now is the time to try all reliable means to produce a profuse perspiration.

"There may occasionally be such extreme cases in which amputation and cauterization by heat or otherwise would be the only available remedies, but as a rule such barbaric treatment need not to be resorted to, and in most cases would probably be a cure worse than the disease.

"Prof. Kauffmann's own directions for the injection of this fluid (chromic acid) are as follows:

"Two or three drops of an aqueous solution (1 to 100) of chromic acid, or permanganate of potash are injected with a Pravaz syringe exactly into the puncture of each fang. It is necessary to let the liquid penetrate into the tissues to the same depth as the venom; the injection must, therefore, be more or less deep according to the size of the snake. To make absolutely sure, three or four more similar injections are made a little distance around the point bitten.

"If, at the time of treatment, the swelling has already obtained a certain size it may be necessary to make injections into various points of the tumor. After the injections the part is pressed gently with the hand so as to distribute the injected fluid in all directions and facilitate its mixture with the venom. Next, some punctures are made with the point of a knife. Usually a rather large quantity of yellowish serosity flows from the wound, mixed with a part of the injected fluid. In order to facilitate this discharge the swelling should be kneaded repeatedly with the hand. Then the surface should be washed with the permanganate or the chromic solution, and a small piece of lint soaked with one or the other of these liquids applied. If, after some time, the swelling continues to grow,

additional injections into the parts must be made as well as punctures. With this treatment the tissues preserve their vitality; the skin does not turn black but remains red. The microbes are destroyed by the injected agents, which act as antiseptics as well as antidotes."

I have copied the treatment for snake bites from Dr. Leonard Stejneger's elaborate work, entitled "The Poisonous Snakes of North America," published by the Smithsonian Institution in 1895.

Subclass **napsida.**

Primarily with single or united temporal arches.

Order TESTUDINATA.

The order Testudinata is divided into three suborders, which may be defined as follows:

No solid carapace, the vertebrae and ribs being separated from a shell consisting of a mosaic of numerous small polygonal bony plates imbedded in a leathery skin; no descending process of the parietal bone; limbs without claws. *Athecae.*

A solid carapace of a few large symmetrical bony plates, not separated from the underlying vertebrae and ribs; parietals with descending processes; limbs with at least one claw each.

Body covered with horny scutes arranged differently from the bony plates beneath; epiplastra and hyoplastra in contact, not separated by entoplastron. Center of last cervical and first dorsal vertebrae articulating with each other. Fourth digit never with more than three phalanges. Jaws covered by horny sheath, not concealed under the fleshy lips. *Laminifera.*

Body covered by an undivided leathery skin without scutes; epiplastra separated by entoplastron from hyoplastra. Last cervical vertebra articulating with first dorsal by zygapophysis only. Fourth digit with more than three phalanges. Jaws concealed under fleshy lips. *Chilotae.*

Suborder LAMINIFERA.

Distinguished by the horny plates which externally cover the shell.

The horny-shelled turtles belong to two different superfamilies, the *Testudinoideae,* corresponding to the groups

Cryptodira, and the *Chelydoideae,* equal to the *Pleurodira.* Only members of the first group enter our State.

Superfamily Testudinoideae.

Neck bending by a sigmoid curve in a vertical plane; cervical vertebrae without or with mere indications of transverse processes; centrum of the last cervical articulating with the centrum of the first dorsal. Mandible with articular concavities; outer border of tympanic cavity deeply notched; pterygoids narrow in the middle, in contact on the median line. Pelvis not anchylosed to the carapace and plastron. Digits with not more than three phalanges. Epiplastra in contact with hyoplastra; entoplastron, if present, oval, rhomboidal or T-shaped. A complete series of marginal bones connected with the ribs.

Family Testudinidae.

Web-footed turtles having the nuchal plate without costiform lateral processes.

The Terrapins constitute the bulk of the species and genera of turtles, widely distributed in the temperate and tropical countries. They live in streams, lagoons, or on land, and are both vegetable and animal feeders. Some species are highly estimated as delicacies. (Stejneger.)

Subfamily Chelydridae.

Nuchal plate with long costiform processes underlying the marginals. Plastral bones nine. Shell covered with epidermal shields. Caudal vertebrae mostly opisthocoelous. Neck completely retractile within the shell. Temporal region incompletely roofed over. No parieto-squamosal arch. Digits moderately elongate. Phalanges with condyles; claws four or five.

Genus chelydra.

No supramarginal shields. Orbit directed outwards and upwards. Tail with large shield inferiorly.

85. Chelydra serpentina Linnaeus. Common Snapping Turtle.

Testudo serpentina, Emys serpentina, Chelonura serpentina, Emysaura serpentina.

Description.—Head rough, covered with soft skin. Snout short, pointed. Eyes superior. Interorbital space narrow. A small pointed pro-

jection at the symphysis of jaws. Alveolar plate narrow. Carapace rugose, with three tubercular keels in adult and young, becoming gradually smoother with age. Vertebral shields much broader than long, at least three-fourths the width of the costals. Marginal plates exclusive of the nuchal 24. Plastron small, leaving the limbs exposed, covered with five pairs of scutes. The bridge very narrow; two or three inframarginals at the outer end of the bridge. Feet broad, webbed to the nails. Fingers five, all with nails. Toes five, the outer one without a nail. The outer border of all the limbs with a sharp fold of skin. Tail long and pointed, nearly as long as, or longer, than the carapace in young, two-thirds or three-fourths the length in half-grown and adult. A strong crest of large compressed tubercles along the median line, which are supported by a bony core. Each side of the tail with smaller tubercles. Under side with two rows of large scales. Skin of neck, under jaw, body limbs and tail covered with wrinkles and large and small warts. A pair of small barbels at the chin.

Color.—Color of carapace chestnut brown to black. Plastron and soft skin whitish or yellowish. Head and upper neck brown.

Size.—A good sized specimen—total length, head and tail outstretched 712 mm. Length of carapace 300 mm.; width 264 mm. Length of plastron 225 mm. Length of tail 280 mm. Circumference of head 250 mm. Weight 19.5 kilograms.

Habitat.—From southern Canada throughout the United States, east of the Rocky Mountains, to Mexico and Ecuador in South America. In Missouri it is found in nearly every stream and pond.

Habits.—The Common Snapping Turtle is mostly found in and near creeks, lakes, ponds and sloughs. It prefers muddy water but nevertheless is also found in clear water. When seen away from water it may either be looking for a place to deposit its eggs or may be crossing from one stream to another. While collecting in St. Clair Co., Ill., in a slough I used what I thought a moss-covered rock for a stepping stone. My foothold began moving and I discovered that I was standing on the back of a thirty-pound Snapping Turtle, which I did not omit to carry home with me. The Snapping Turtle is carnivorous and lives wholly on fish, crayfish, frogs, small rodents and small and young water fowl. A farmer once told me that he lost many a young duck on account of the Snapping

Turtles in a pond nearby. He witnessed the capture of a duckling by a Snapping Turtle on the pond. My son, while collecting around a clear water slough, saw the head of a turtle sticking out among the rubbish. Mistaking it for another turtle he reached down. He withdrew his hand almost immediately but not before the turtle had torn quite a triangle into the palm of his hand. The wound gave him considerable trouble for some time. Thirty years ago no one would eat a Snapper, but now it is considered a delicacy and brings a good price on the market. The Snapping Turtle deposits her eggs in holes along the banks of creeks in June, and covers up the holes so nicely that only an expert can discover them.

Genus MACROCHELYS.

Head very large, with symmetrically disposed shields above. Orbits looking outward and forward. Alveolar plates very broad, strong pointed projections at the symphysis of the jaws. Carapace with three prominent keels, which persist throughout life. Three scales on each side between the costal and the marginal rows. Tail with three series of tubercles above, inferiorly covered with small scales.

86. MACROCHELYS LACERTINA Schweigger. Alligator Snapping Turtle.

Chelonura temminckii, Emysaurus temminckii, Gypochelys lacertina, Macroclemys temminckii, Macroclemmys temminckii, Macroclemys lacertina.

Description.—Head extremely large, broad behind, tapering rapidly to the acuminate beak and snout. Beak of upper jaw projecting beyond the lower and strongly hooked, the outline of the cutting edge rising from the point of the beak, then descending to the middle, and again rising to the corner of the mouth. Lower jaw turned up into a strong hook. Head covered with large symmetrical plates. Eyes lateral and widely separated. Neck short, which has, like the chin, many small dermal flaps. Carapace furnished with three prominent keels, which do not vanish with age. Each median scute rises posteriorly into a knob, which is largest on the hindermost vertebral scute. The lateral keel is located on the upper ends of the costal scutes. Between the lower ends of the anterior three scutes and the marginals are three or four supra marginals. Posterior border of the carapace serrated. The tail is about three-fourths the length of the carapace,

furnished above with three rows of low tubercles, below with rows of smaller scales.

Size.—Total length from end of beak to tip of tail 1525 mm.; length of carapace 625 mm.; width of carapace 533 mm.; length of plastron 445 mm.; length of tail from vent 354 mm.; circumference of tail at vent 265 mm.; length of head 229 mm.; circumference of head 635 mm.; circumference around widest part of body 1245 mm. Weight 148 pounds or 67.5 kilos.

Habitat.—Rivers and lagoons. All the rivers emptying into the Gulf of Mexico from western Texas to western Florida, northward to the "Sunken Lands" of Missouri. Once common in the Mississippi River. Missouri localities:—Cottonwood Point, Caruthersville, Pemiscot Co., and in Stoddard and Butler Counties.

Habits.—Ditmars in his Reptile Book gives the following very interesting account of this giant fresh-water turtle.

"Its pale brown hues well match the muddy waters it inhabits. With its colors in perfect harmony, it lies motionless on the soft bottom, ready to seize, with lightning-like dart the unsuspicious fish that comes its way. While thus resting it is able to entice its prey by a remarkable appendage attached to the inside of the lower jaw, close to the region of the tongue. This is a well-developed filament of flesh, white and distinct from the yellowish mouth-parts and resembling a large grub to such a degree of nicety that the popular-minded observer, seeing the object in the reptile's mouth would declare it to be the larva of some insect. More striking, however, is the reptile's power to keep this appendage in motion, giving it the aspect of crawling about in a small, circular course.

"With the mud-colored shell lying close to the bottom, the jaws thrown open to a great extent, this organ is put in motion. Every other portion of the creature is as motionless as a rock. In this position of rigidity the shell looks like a great, round stone and blotches of fine, moving moss intensify the deception; the big head looks like an-

other stone, beneath which there is a cavern and in this cavern crawles the white grub, to all appearances an object dear to the hearts of finny wanderers. But woe to the luckless fish that swims within the reach of those yawning jaws!"

The strength of the jaws of this turtle is enormous. The specimen from Caruthersville—of which I have given the dimensions above—would, when teased with a broom stick, break it in two.

Subfamily Kinosternoidae.

Head large, pointed in front; snout projecting. Eyes situated far forward. Lower jaw terminating in a sharp point. Neck completely retractile within the shell. Carapace elongate, convex, smooth. Plastron moderately large, rounded in front, truncate or slightly emarginate behind. Limbs slender. Feet short. Digits moderately developed and webbed. Five fingers and four toes with claws. Tail terminating with a nail. Males with a patch of small horny, keeled tubercles on the hinder side of the leg and another below the thigh.

Key to the Missouri Genera.

Plastron narrow, its hind lobe not more than one-half the width of the carapace. Wings of abdominal plate narrow, not grooved behind. Head of moderate size, with no plate above. *Aromochelys.*

Plastron wider, its hind lobe considerably wider than one-half the carapace. Wings of abdominal plate wide, with a deep groove behind. Head large with a rhomboidal plate above. *Kinosternon.*

Genus Aromochelys.

Two species of *Aromochelys* occur in the State of Missouri, distinguished from each other as follows:

Two yellow stripes on side of head from tip of snout, above and beneath the eye, to the neck. Carapace of adult not keeled. *odorata.*

Two yellow stripes on side of head, one from snout above the eye to the neck, the other from above the angle of the jaw to the neck. Carapace in adult not keeled. *tristycha.*

87. Aromochelys odorata Latreille. Common Musk Turtle. Stink Turtle.

Testudo pennsylvanica, Testudo odorata, Testudo glutinata, Emys odorata, Terrapene odorata, Terrapene boscii, Cistudo odorata, Sternothoerus odoratus, Staurotypus odoratus, Ozotheca odorata, Cinosternum odoratum, Aromochelys odoratus.

Description.—Head large, snout conical, jaws very strong. No point at symphysis of upper jaw. Two to four gular tentacles. Numerous small tubercles in series on the skin of the neck. Shell elongate, convex, smooth or with an indistinct vertebral ridge in adults, distinctly keeled in young. Nuchal plate small, elongate and widest behind in adults. First dorsal about half as wide behind as in front, the three following dorsals hexagonal; last dorsal about half as wide before as behind. Costals very large. Marginals, excepting one on each side of the two caudals, narrow and elongate; the two marginals next the caudals equal to the caudals in size and about twice the width of the other marginals. Plastron small, rounded anteriorly, emarginate posteriorly. A single small gular; postgulars small, pectorals large. Axillaries and inguinals meeting, and with the wings of the large abdominal plates forming the bridge between the plastron and the carapace. Anterior feet with three transverse scales on their anterior surface and with a few small ones on the palms. Hind feet with transverse scutes on the heel. Digits 5-4, claws sharp and curved. Skin of legs and tail with numerous papillae. A curved nail on the end of the tail.

Color.—Shell brownish black above and below in adults, more or less yellowish in young. Often shell is streaked with darker. The seams of the plastron are marked with yellow. Head greenish olive or black with several stripes of yellow. A narrow stripe extends from the tip of the snout over the eye to a spot on the side of the head and along the neck. Another stripe of the same color extends from beneath the nostril underneath the eye to and along the neck. There is a short stripe on each side of the lower jaw, which may continue posteriorly on the skin of the neck.

Size.—Length of shell 121 mm.; width of shell 80 mm.; depth 45 mm.

Habitat.—Southern Canada to the Gulf of Mexico, westward to Missouri in the north and to Texas in the southern portion. Missouri localities:—Caruthersville, Pemiscot Co., Gainesville, Ozark Co., Carthage, Jasper Co., Osage River. In Illinois, Madison and St. Clair Counties.

Habits.—The Musk Turtle frequents slow-running streams, muddy lakes and sloughs. When picked up it

emits a strong odor. I have often found them out of water early in the morning. Otherwise they seldom leave it. Frequently they are caught on fish hooks baited with small fish or worms. Ditmars gives an experiment he made with several of these turtles. He kept them in a deep aquarium without means of leaving the water or of obtaining a foothold on top to breathe. The test continued for several weeks. These turtles either crawled along the bottom of the bank or swam leisurely to the surface for a breath of air. They fed readily and from all indications would have lived indefinitely under such conditions. Pond turtles or River turtles—terrapins—if thus treated would have soon become exhausted and ultimately succumbed by drowning. The eggs are 28 mm. long by 15 mm. in diameter, cylindrical with spherical ends.

88. Aromochelys tristycha Agassiz. Southern Musk Turtle.

Ozotheca tristycha, Sternothoerus tristycha.

Description.—Agassiz in his Contributions to Natural History of the United States, on page 425, says: "Although *Ozotheca odorata* varies greatly, not only in color, but even in outline, I have no doubt that this is a distinct species, characterized, when young, by the great prominence of the keels upon the vertebral and costal plates and by numerous dark dots between the scales of the sternum and, when adult, by a marked difference in the form of the snout. In *Ozotheca odorata* the snout is much more prominent on account of the slope of the upper jaw, which extends further back and is therefore less steep, than in *O. tristycha*, the lower jaw of which is broader below the symphysis than in *Ozotheca odorata*, and suddenly turned up."

The upper shell is more elongated, while the forward, central shield of the carapace is much narrower.

Color.—The color of the upper and lower shields is like that of the preceding species. There is a narrow stripe from the snout, extending over the eye, thence back upon the neck. Beneath this is a second stripe, extending from slightly above the angle of the jaw, backward upon the neck. The chin has spots in place of the two light bands of *A. odoratus*. With some specimens the head bands are very obscure. These are generally old individuals and the head is brown, streaked or speckled with black. (Ditmars.)

Habitat.—Texas to Florida. Agassiz states in his Contributions to the Natural History of the United States, "This species is only found in the Western and Southwestern States." He says he has received many specimens collected by Mr. G. Stolley in the Osage River in Missouri and in Williamson Co., Texas.

Habits.—The habits of the Southern Musk Turtle are no doubt similar to those of the preceding species. Up to this date I have not been able to secure a specimen from the Osage River. The specimen I recorded from Ozark Co., Mo., (Trans. Acad. Sci. St. Louis **13**: 82. 1903.) proved after a careful examination to be *A. odoratus.*

Genus KINOSTERNON.

Head large, with a large rhomboidal plate above. Plastron almost equal to length of carapace, with its anterior and posterior lobes nearly equal in length, both freely movable on the middle fixed portion and capable of closing the shell. Posterior lobe emarginate behind, its angles rounded. Carapace elongate, convex and smooth in the adults. Tail with a terminal nail.

89. KINOSTERNON LOUISIANAE Baur. Louisiana Mud Turtle.

Description.—Shell much like *K. pennsylvanicum*, but more elongate. Skull different. The lateral hook in the middle of the maxillary very much developed and very sharp. Median hook on symphysis not so strong. Postorbital arch stronger than in *K. pennsylvanicum.* Lower jaw very strong, ending in a sharp point; symphysis of lower jaw larger than vertical diameter of orbit. Four barbels, two just behind the symphysis near together, and two farther behind more separated.

Color.—A yellow-orange stripe from snout over upper part of orbit along the neck; another one from the angle of the mouth to the neck. Limbs and necks olive gray, a few yellow spots on top of posterior part of head. Lower jaw with grayish yellow dots and lines. Webs more developed than in *K. pennsylvanicum.*

Size.—Length of carapace 106 mm.; width of carapace 74 mm.; length of plastron 103 mm.; width of front lobe at hinge 53 mm.; width of rear lobe 48 mm.

Habitat.—Louisiana westward well into Texas and up the Mississippi Valley to Southeastern Missouri. Missouri localities:—Butler County.

Habits.—The habits of the Mud Turtle are strictly aquatic. They prowl about the muddy bottoms of rivers and ponds in search of food. My son caught this turtle in Grinnell's Lake, near Poplar Bluff, Butler Co., April 29, June 6, and September 5th.

Subfamily Emydinae.

Web-footed turtles having the nuchal plate without costiform lateral processes.

The terrapins constitute the bulk of the species and genera of turtles, widely distributed in the temperate and tropical countries. They live in streams, lagoons, or on land, and are both vegetable and animal feeders. Some species are highly esteemed as delicacies. (Stejneger.)

Shell bony, moderately depressed or strongly convex, covered with horny plates, of which there are five dorsals, eight costals, one nuchal, twenty-two marginals, two caudals, twelve sternals, and generally two axillaries, and two inguinals. Head of moderate size, covered with a smooth, soft skin, retractile within the cavity of the shell. Jaws naked. Digits 5-4, generally fully webbed, rarely imperfectly so.

Key to the Genera in Missouri.

Plastron and carapace immovably united by a bony symphysis; no hinge across the middle of plastron.
- Alveolar surface of jaws narrow.
  - Alveolar groove well marked, except in front; toes strong, broadly webbed and spreading; hind feet largest; carapace rather flat. *Chrysemys.*
- Alveolar surface of jaws broad.
  - Alveolar surface of upper jaw with a submedian ridge, parallel to margin; toes short and strongly webbed; head with thin, hard skin; upper jaw notched in front. *Pseudemys.*
  - Alveolar surface of jaws smooth; in front part of upper a deep groove; toes short; head covered with soft skin; upper jaw not notched in front. *Malaclemys.*

Plastron and carapace united by a cartilaginous lateral suture; plastron hinged across the middle.
- Body short and high; plastron rounded or truncate in front and behind; feet nearly free of webs. *Terrapene.*

Genus CHRYSEMYS.

Alveolar surface of upper jaw rather narrow, widest behind. Median ridge not prominent. Upper jaw with a notch in front, on each side of which there is a small tooth. Shell broad and flattened, no concentric grooves on shields. Claws long.

Key to the Species of Missouri.

Carapace smooth and rounded, without a keel and not serrated at the rear margin.

- Bright red markings on upper and lower marginal shields of carapace. Carapace dark olive, the shields with narrow yellowish margins. Plastron blood red in life, with an obsolete oblong dark patch in the middle. *treleasei.*
- Carapace dark olive or brown, the shields with narrow or no yellow margins, but traversed by vein-like yellow lines. Plastron with symmetrical black markings over the larger part. *belli.*
- Carapace dark olive brown, the shields with narrow yellowish margins. The yellow median stripe along the back is broader than in any other species. Plastron plain yellow. *dorsalis.*

90. **Chrysemys treleasei**, n. sp.[7] Trelease's Turtle.

Description.—Carapace depressed, quite smooth on the middle part. No keel in the adult. The young of the first to the third year have a faint keel. Nuchal elongate, nearly rectangular. The second, third and fourth vertebrals are hexagonal, the anterior suture of the second and the posterior one of the fourth concave. The two intermediate sutures are straight or nearly so. The lateral sutures of these three scales have a sinuous projection outward in the middle to connect with the sutures of the costals. Costals plicated longitudinally for nearly one-half from the outer edge. Marginals adjoining the two middle costals also with one or two longitudinal pliae. Plastron large, as long as the opening of the shell, front and hind edge truncate. The shortest median suture is between the humerals. Inguinal and axillary large, the latter the larger. In old specimens the median and transverse sutures of the plastron are followed by one or two parallel pliae.

Head moderate, snout short, a little projecting. Upper jaw with a small median notch and a small cusp on each side, the edge not or but slightly serrated. Alveolar surface moderately broad, with a feeble

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[7] Named in honor of Professor William Trelease, President of the Academy of Science of St. Louis.

median ridge. Digits webbed to the claws, which are of medium length in the adult. Vent projecting outside of the shell in the male.

Color.—Carapace dark brownish olive or black. The yellow borders of the scales very narrow and do not form bands right across the back. A yellow narrow streak along the median line of the back. The top of the marginals is lined with crescentic and straight yellowish lines. On the underside these lines are red. The plastron is uniform blood-red in the adults, which color partly fades away in alcoholic specimens. When the red has faded the plastron sometimes shows a faint long and wide blackish mark. In the young of the first year, the red plastron is divided into squarish fields by the proportionately wide yellow sutures. These markings disappear after the third year. On top of the shell all the sutures are of a rather wide band of grayish. The soft parts are dark brown or blackish, nicely marked with yellow, symmetrical lines and bands on the head, and orange red bands on the neck, limbs and tail. The yellow bands under the chin usually form a fork in the middle, the prongs projecting backward. Another yellow line starts from below the nostrils, runs through the posterior end of the jaws, ending below the orbit. Two yellow lines start also at the nostrils, running through the eye, the lower one—the wider—on the side of the neck to the body, the upper one stopping above the tympanum. There are numerous narrow lines parallel to these heavier ones.

Size.—Length of carapace 146 mm.; width of same 110 mm.; total depth 51 mm. Length of plastron 141 mm.

Habitat.—So far I have only found this turtle on the east side of the Mississippi River, in Madison, St. Clair, and Monroe Counties, Ill.

Habits.—The Red-bellied Turtle used to be common in the slow running creeks, ponds and sloughs some thirty years ago, but is now quite scarce. Wading in the shallow sloughs I found most of my specimens in June.

91. Chrysemys belli Gray. Bell's Turtle.

Chrysemys cinerea var. belli, Chrysemys oregonensis, Chrysemys nuttalii, Chrysemys pulchra, Chrysemys picta part, Clemmys oregonensis, Clemmys picta var. b and c, Emys oregonensis, Emys belli.

Description.—Shell depressed; no keel; uniformly concave above; margins nearly continuous; a very slight notch behind; nuchal plate elongated, nearly parallel and notched in front. Plastron truncate behind; outer angles of gulars projecting. Head medium in size; jaws weak. Fingers and toes fully webbed; nails strong and sharp. (Garman.)

Color.—Color above greenish olive with narrow yellowish lines following the sutures. Some of the shields are traversed by vein-like lines of the same color. Marginals above with about three transverse lines, the median of which reaches the inner margin of plate and sometimes joins a yellow band along the outer margin. Marginals beneath with a broad band traversed by yellowish stripes. Within the fields formed by these stripes are dark circular spots with a yellowish center. The connection between the plastron and marginals has three, sometimes interrupted, yellowish red stripes. The plastron is red with the central region occupied by a large blackish lyriform blotch, which is marbled by pale yellow and sends rays out along the sutures. Head and legs are striped with red. A yellowish stripe from below the nostril in front to the end of the jaw. Two other lines of the same color join at the nose, run to and through the orbit, and end above and below the tympanum. Three other yellowish red stripes, one starting at near the corner of the mouth, the other through the tympanum and the third on the occiput, run parallel along the neck to the body. A yellowish stripe starts at the symphysis of the lower jaw, behind which it bifurcates and with another one in the middle of that space runs back on the lower side of the neck to the body. Besides this the whole head and neck are marked with a number of very narrow yellowish parallel lines. On the front side of the fore legs are four reddish stripes, one on each side and two in the middle, which reach to the end of the fingers. Webs largely pale yellow. On the posterior side of the hind legs are two reddish yellow bands, which start from the body, running nearly parallel and converging at the tail, from where they run out in a single stripe on the lower end of the tail to its tip. On each side of the upper side of the tail are also two of these stripes, which join and run out to the end of this member.

Size.—Length of carapace 160 mm.; width of same 116 mm.; depth of shell 63 mm. Length of plastron 150 mm.

Habitat.—From Minnesota to the Rocky Mountains, south to Texas. Common on both sides of the Mississippi River in the neighborhood of St. Louis. Missouri localities:—St. Louis, St. Charles, Montgomery and Pettis Counties. Illinois localities:—Randolph, Monroe, St. Clair, Madison, and Adams Counties.

Mr. G. Stolley, who collected a number of these turtles in the Osage River, and Dr. George Engelmann, of St. Louis, sent Professor Agassiz the material which he described in his Contributions to the Natural History of the United States, Vol 1, 1857.

Habits.—Bell's Turtle is common in the neighborhood

of St. Louis, nearly every pond or slough, or slow running creek being inhabited by it. They are seldom found in the Mississippi River, preferring quite muddy water. On a sunny day one may observe small colonies of them lying on partly submerged logs. At the least noise they drop into the water. In February, while the creeks are still covered with ice, they may be seen lying at the bottom.

92. CHRYSEMYS DORSALIS Agassiz.

Chrysemys picta var. dorsalis. Chrysemys picta part, Clemmys picta var. d.

Description.—Size and structure of the shell like the preceding, except that the carapace is more elliptical in outline, and the dorsal scales are proportionally wider. Margin of the costal scales plicated. Sternum uniformly yellow, deep red in spring. The yellow median line along the back is broader than in any other species of *Chrysemys*. The marginal scales are not so highly ornamented. The head markings as well as those of the feet and tail are similar to the preceding species. The young are nearly circular in outline and the reddish-yellow streak on the back very pronounced.

Size.—Length of carapace 100 mm.; width 88 mm.; height 33 mm. Length of plastron 87 mm.

Habitat.—From the Gulf of Mexico up the Mississippi River to the southeastern part of Missouri. Missouri localities:—Dunklin, Stoddard and Butler Counties.

Habits.—This is a truly aquatic turtle found in lakes or creeks and common in the extensive overflow of the St. Francis River in the "Sunken Lands."

Genus PSEUDEMYS.

Carapace moderately depressed, posterior part of margin slightly serrated. Young with a distinct keel. Plastron truncate in front, emarginate behind. Wings of pectoral and abdominal plates well developed. Axillary and inguinal plates rather large and about equal in size. Alveolar surface of jaws rather wide, with a median ridge parallel to their margins. Digits 5-4, fully webbed. Fingers with long, slightly curved claws. The clawless fifth toe of the hind foot forms an angular projection on the posterior edge of the foot. Fore legs covered with band-like scales.

Key to the Species of Missouri.

Ridges on alveolar surfaces of jaws smooth. Both jaws with smooth edges.
- With a broad red or orange stripe on each side of head. Carapace with yellow stripes. *elegans.*
- Without orange stripe on head. Markings of head and neck obscure. Carapace without yellow stripes. *troosti.*

Ridges on alveolar surfaces of jaws tuberculate. Lower jaw with serrated edges. *texana.*

93. Pseudemys elegans Wied. Elegant Turtle.

Emys cumberlandensis, Trachemys elegans, Emys elegans, Chrysemys scripta var. elegans, Chrysemys elegans, Clemmys elegans, Emys holbrookii, Trachemys holbrookii.

Description.—Carapace broad, moderately compressed, convex, with a slight keel in the young. Posterior marginal plates obtusely serrated. Surface of carapace smooth or wrinkled longitudinally. Nuchal very narrow. Plastron truncate in front and emarginate behind. Anterior lateral angles of the gulars produced. Longest suture of the plastron the one between the abdominals, the shortest the one between the humerals. Upper jaw with a median notch, lower jaw with a corresponding median hook. Bridge rising rapidly to the margin of the carapace.

Color.—Color of the carapace olive, with lines and spots of yellow and black. On the vertebral scutes the lines run mostly lengthwise, on the costals transversely. Down the middle of each costal scute runs a yellow band of varying width. Parallel with it are other lines and bands of black and yellow, narrow or wide. On both the upper and lower surfaces of the marginal scutes are sutural spots, consisting of concentric circles of yellow and black. Between them a yellow band crosses each marginal. The plastron is yellow, with a black blotch on each scute, these often ocellated with yellow. The spots on the bridge usually confluent. Head with numerous narrow stripes of greenish or yellow. A broad stripe starts under the eye and runs back on the neck, being met at the angle of the jaw by a stripe from the middle of the lower jaw. Another stripe, blood-red in life, yellowish when preserved, starts at the posterior corner of the eye and runs back on the neck. The legs and tail are striped with yellow. (Hay.)

The specimen of which the measurements are given has the plastron entirely black with the exception of the front edge of the gulars, the outer edge of the post-gulars and preanals, which are yellowish.

Size.—Length of carapace 230 mm.; width 152 mm.; depth 102 mm. Length of plastron on median line 218 mm.—sometimes as long as 260 mm.

Habitat.—The Cumberland Turtle is found inhabiting the territory from South Carolina to Mexico and north along the tributaries of the Mississippi to the Yellowstone. Missouri localities:—St. Louis, Jefferson, Butler, Stone, Pemiscot, Newton, Saline, Pettis, and St. Charles Counties. Osage River (L. Agassiz). Illinois:—St. Clair and Madison Counties.

Habits.—This species is rather common in the neighborhood of St. Louis on both sides of the Mississippi. It is truly aquatic. I had some in captivity which became very tame and fed out of my hand.

94. Pseudemys troostii Holbrook. Troost's Turtle.

Emys troostii, Chrysemys troostii, Trachemys troostii.

Description.—Shell moderately convex, the slope gradual in front and expanded above the insertion of the posterior legs, slightly depressed inwardly. Third, fourth and fifth dorsal plates with an obscure, rounded ridge. Costal plates and the first and fifth (sometimes all) dorsals longitudinally plicated. Nuchal narrow, long; the two adjacent marginals with the outer edges projecting. Posterior four marginals of each side without outer angles, each with a marginal notch. Plastron a little rounded in front, nearly truncate. Outer angles of the gulars projecting considerably, the anterior edge roughened. Plastron broadly emarginate behind. Head rather large, jaws strong, the upper with a median notch, the lower with a corresponding hook. Tympanum well marked. Feet strong, the posterior pair much expanded and strongly webbed. Claws on front feet very long and slightly curved. Those on the hind feet only about half the length of the anterior ones.

Color.—Carapace greenish olive mottled and blotched with black. The black confined mostly to the margins. Marginals beneath with black oblong spots. Plastron pale yellow and black, the latter extending along the median suture as a wide, black stripe. The black stripes on the transverse sutures are not as wide. Head dusky, obscurely and finely mottled above and on the sides, below narrowly striped with greenish. Jaws horn-color with vertical dashes of black on the upper, and longitudinal ones on the lower. Feet and tail dusky yellow with indefinite markings.

Size.—Length of carapace 224 mm.; width of same 163 mm.; depth 88 mm. Plastron 186 mm. long.

Habitat.—Mississippi River and its tributaries from the Gulf to northern Missouri. Missouri localities:—St.

Louis, Stoddard, Pemiscot, and Pettis Counties. (Osage River, Agassiz). In Illinois, Monroe, St. Clair, and Madison Counties.

Habits.—The Troost's Turtle is common in the Mississippi River and in the adjoining lakes and sloughs left by the receding water. They are mostly captured by seining. With *Pseudemys elegans* a great many are sent to the markets of eastern cities. On a visit to Baltimore many years ago I found at a fish market a barrel full of these two turtles, which the owner told me had come from St. Louis.

95. PSEUDEMYS TEXANA Baur. Texas Turtle.

Chrysemys texana.

Description.—Shell very thin behind, flaring; posterior border serrated, longitudinally plicated. Nuchal long and slender. Shell not much elevated. Plastron emarginated, slightly in front, stronger behind. Skull small. Edge of upper jaw smooth, with a slight notch in front; edge of lower jaw strongly serrated with a hook at the symphysis. Upper and lower alveolar surfaces of both jaws with large, tooth-like tubercles. A strong fringe is formed by the scales on the outer edge of the front legs.

Color.—Upper shell brown, with yellow concentric rings. Plastron yellow or with brown markings. A yellow streak from the point of the nose on the median line of the head to the occiput. A yellow streak starts over the eye, widens at the side of the occiput, and continues along the side of the neck. Another streak commences on the upper hind corner of the eye and ends in the shape of a hook in front of the tympanum. Another heavy streak starts at the middle of the lower jaw and, arriving below the tympanum, sends a branch upward towards the eye. Three very strong and some slender yellow stripes on the lower face of the neck.

Size.—Length of carapace 232 mm.; width of same 177 mm.; depth of shell 74 mm. Length of plastron at the median line 208 mm.

Habitat.—Northern Mexico, Texas, Oklahoma, and western Missouri. I received my first specimen of the Texas Turtle from Mr. J. H. Black, of Baxter Springs, Kansas, who caught it in Newton Co., Missouri. The second one came from Mr. J. C. Miles, of Carthage, Mo.,

who stated that they were often caught when seining in Spring River, Jasper Co. Spring River flows into the Neosho River, a confluent of the Arkansas. A third specimen I found dead on the edge of a creek near Paris, Texas.

Habits.—This terrapin occurs principally in rivers with muddy beds.

Genus MALACLEMYS.

Shell depressed with a distinct keel. Bridge wide, with the axillary and inguinal processes well developed, the latter united to the fifth costal plate. Entoplastron lying wholly in front of the suture between the humerals and pectorals. Jaws with the alveolar surface broad to very broad and entirely without a median ridge. Skull without a bony temporal arch. Digits strongly webbed. (Hay.)

Key to the Species of Missouri.

Comma-shaped yellow mark behind each eye. Keels of second and third dorsal plate concave before the tubercles. *lesueuri.*

Spot behind the eye not comma-shaped. Keels of second and third dorsal plates uniformly convex before the tubercles. *geographica.*

96. Malaclemys lesueuri Gray. Map Turtle. Saw-back Turtle.

Emys lesueurii, Emys pseudo-geographica, Malacoclemmys lesueurii, Malaclemys lesueurii, Malaclemys pseudo-geographica, Malacoclemmys pseudo-geographicus, Clemmys pseudo-geographica, Graptemys lesueurii, Graptemys pseudo-geographica.

Description.—Shell oval, depressed, rising roof-like to a distinct median keel. Posterior border of some or all of the vertebral scutes with each a prominent tubercle, largest on the second and third vertebrals. Shell strongly serrated behind. Nuchal with a notch in its hinder border. Plastron with its hinder lobe not much over one-half the width of the carapace; a broad shallow notch in its hinder border. Bridge broad and flat, rising little towards the carapace. Head of males small; that of the females rather large. Cutting edge of upper jaw smooth, convex, the jaw not notched in front; the alveolar surface of moderate width, wholly separated in front by soft skin. Lower jaw smooth, concave cutting edges, not hooked at the tip. Limbs well developed; the digits webbed to the bases of the claws. Tail of male, as with most of the turtles, bringing the vent beyond the edge of the carapace. (Hay.)

Color.—Color of the upper surface of the carapace olive or brownish, usually with black blotches on the dorsals, costals, and marginal scutes. The tubercles on the dorsal ridge are of the same black color. Over all the scutes of the carapace is a net-work of greenish lines. The plastron is yellowish in the adults, with some irregular darker markings. In the young the markings on the plastron remind one of Bell's Turtle. Bridge uniform brownish with numerous streaks of yellow and brown. Head, neck, limbs and tail dark green with stripes of yellow and rows of small yellow spots. Behind the eye is a very characteristic transverse, proportionately wide, streak of yellow, which runs backwards on the top of the head, nearly in a right angle, to the transverse blotch. Another yellow streak from the point of the nose over the median line of the head and between the two angular marks. A yellow spot under the eye.

Size.—Length of shell 170 mm.; width of same 136 mm.; depth 71 mm. Length of plastron on median line 153 mm. These turtles sometimes reach a length of 254 mm.

Habitat.—Mississippi Valley north to Wisconsin, west from Ohio to Kansas. Missouri localities:—St. Louis, Jackson, Dunklin, Pemiscot, St. François, Pettis, and Cooper Counties. Osage River (M. G. Stolley). In Illinois, Madison, St. Clair, Monroe, and Randolph Counties.

Habits.—The Map Turtle is an eminently aquatic terrapin, spending its life in rivers, lakes and ponds. Sometimes quite a number of them can be seen sunning themselves on rocks and fallen trees. The food consists of small fish and crayfish. Professor Garman states that he found the bulbs of sedge in their digestive canal. According to Professor Louis Agassiz this species deposits its eggs earlier in the season than any other of our fresh water turtles. He also states that they do not lay eggs before their eleventh year.

97. MALACLEMYS GEOGRAPHICA Lesueur. Geographic Terrapin. Map Turtle.

Testudo geographica, Emys geographica, Emys megacephala, Terrapene geographica, Graptemys geographica, Clemmys geographica, Malacoclemmys geographicus, Malaclemmys geographica, Malacoclemys geographicus.

Description.—Carapace depressed, bluntly keeled. Keels of dorsal plates regularly convex, posterior tubercles not very prominent. Outer

margin of posterior marginal plates slightly serrated. Nuchal narrow, its hinder edge notched. Bridge wide, rising little toward the carapace. Plastron slightly or not at all emarginate in front, but distinctly so behind. Anterior outer angles of gulars slightly produced. Axillary and inguinal plates about equal. Posterior margin of anal plates angulate. Head smaller in males, larger in females. Alveolar surface of jaws very wide, the inner edges almost meeting. Upper jaw with the cutting edge smooth, somewhat sinuated, not notched in front. Lower jaw flat, not hooked at the tip.

Color.—Carapace dark olive brown, marked all over with a network of greenish lines. The tubercles of the dorsal scales are blackish. Upper and lower marginals with diffused blackish sutural marks, which enclose irregular lines of yellow on the underside. Head, neck, limbs and tail dark green, almost black, with numerous lines and streaks of greenish yellow. Behind the eye is a triangular spot of greenish yellow, often elongated backward. Plastron yellow with the sutures of the scutes marked with dark lines. In young specimens about 80 mm. long the plastron is marked with a large lyri-form blotch of brown, which looks as if the colors had already faded out.

Size.—Length of shell 180 mm.; width of same 138 mm.; depth 60 mm. Length of plastron on median line 158 mm.

Habitat.—From Pennsylvania and New York to Michigan and Arkansas. Missouri localities:—St. Louis, Stone, and Jasper Counties. In Illinois, Madison, St. Clair and Monroe Counties.

Habits.—The Geographic Turtle is a truly aquatic species, but is not so abundant as the preceding. It lives almost exclusively on mollusks, as the unusual width of the jaws would suggest. Young specimens eat thinner shelled mollusks. This species together with the Cumberland and Saw-back Turtles are brought in great quanties to the St. Louis markets.

Genus TERRAPENE.

Shell high and very convex, highest before the middle. Plastron large, rounded before and behind, capable of completely closing the shell. The plastron is united to the carapace by a ligament, movable on it. The axillary inguinal processes rudimentary. Plastron divided by a transverse hinge in two movable lobes. The hinge covered by the suture between the pectoral and abdominal scutes. Entoplastron cut by a suture between the humerals and the pectorals. Alveolar surface of jaws narrow, without median ridge. Upper jaw with the beak pro-

jecting downward. Choanae between the eyes. Skull without bony temporal arch. Digits with short webs or none.

Key to the Species of Missouri.

Shell with traces of keel, rounded above, no bridge. Hind feet with four toes. *carolina.*

Shell as in *carolina.* Hind feet with three toes. *kinosternoides.*

Shell without traces of keel, flat above, a distinct bridge. *ornata.*

98. Terrapene carolina Linnaeus. Carolina Box Turtle.

Testudo carolina, Testudo carinata, Testudo clausa, Testudo virgulata, Testudo incarcerata striata, Emys clausa, Emys virgulata, Emys schneideri, Terrapene clausa, Terrapene nebulosa, Cistudo carolina, Cistudo clausa, Cistudo clausa clausa, Cistudo virginia, Terrapene carinata, Testudo tessellata minor caroliniana.

Description.—Carapace very convex with at least a trace of an obtuse vertebral keel, which is more distinct in the young. Vertebral shields broader than long and narrower than the costals. Posterior marginals flared outward. Caudals directed downward. Plastron tightly closing the shell, without trace of a bridge. Broader posteriorly than anteriorly, rounded in front and behind. Upper jaw hooked, the hook entire. The lower jaw turned upward at the tip. Alveolar surfaces narrow. Limbs and feet scaly. Digits with very indistinct web. Claws stout. Tail short.

The quadrato-jugal is rudimentary and is not connected with the jugal. Hence the bony zygomatic arch is incomplete. The number of phalanges in each hind foot is 2-3-3-3-2. (Baur.)

Color.—The colors of the carapace are yellow, brown or black. Sometimes the darker color predominates, sometimes the yellow. Usually the ground is brown or reddish brown, while the yellow appears as spots of various shapes; often radiating from the point of growth of the scute. The ground color may appear to be yellow, relieved with black spots. The plastron is variously ornamented with black and yellow. The head, neck, limbs, and tail are brown, with spots of orange. Sometimes the plastron is all over ebony black. The young have a single yellow spot on each of the scutes of the carapace. (Hay.)

Size.—Length of carapace 128 mm.; width of same 102 mm.; depth 73 mm. Length of plastron 132 mm.

Habitat.—New England States south to the Gulf, westward to the Mississippi River. So far I have only one specimen captured on the west side of the Mississippi

River. (See Transactions of the Academy of Science of St. Louis, **6**: 261.) Later on I found this species quite common in all the counties bordering the Mississippi in Illinois—Madison, St. Clair, Monroe, Randolph, and Union Counties.

Habits.—Mr. W. C. Whelpley of Cobden, Union Co., Ill., in a letter dated July 16, 1904, gives the following account of the Carolina Box Turtle:—"Where to look for terrapins. I took a sack and went to the old limestone spring, where the water comes out on the north side of the hill in the woods. A small stream runs down the hill about 75 feet to a low swampy ground, which is grown up very heavy with willows, cat-tails and swamp grasses. This makes it a very cool and wet place the year round. I was looking very carefully for turtles, when my eyes fell on the top of a terrapin shell in the mud at the roots of a large tree, where for a few feet around there was no grass or weeds. The water was about one-half inch deep on one side of the tree and dry ground on the other side. I stepped over to reach the turtle, and I could see the print or form of another shell in the mud. I then procured a stout stick and began to probe in the mud. Within five minutes' time, I found six turtles in this mudhole, three feet in diameter. About ten feet from the above space and further down the hill I found another mudhole and in it two more terrapins; about three feet further down in a similar place I found three more of these animals. All of them were under the surface of the ground except the first one that I found. Some of them were fully eight inches below the surface, but in each instance I found a place, where the turtle could reach the air by raising its head about one inch from under the water. After finding these eleven terrapins I think I have learned where to look for them in warm weather."

The same gentleman reports in another letter, dated July 26, 1904, the following experience:—"I was standing near a thick growth of high grass which surrounded

a bare spot of ground about three feet in diameter. I heard a noise which sounded like a rat gnawing a bone. At first I could not locate the noise. I soon found, however, that it came from the bare spot of ground. Carefully stepping closer, I found a large barn rat gnawing the front edge of the shell of a Box Turtle, which lay on its back. The rat soon saw me and ran for the barn. I picked up the turtle, which was covered with blood. This came from the place where the rat had gnawed the shell and also from one hind leg which the rat had bitten. The turtle was very, very fat, so fat that it could not entirely close the shell. The rat had evidently attacked the hind foot, which the turtle was unable to draw in under the shell. I wonder whether the rat attacked the turtle while travelling. Did the rat turn the turtle over to prevent it from getting away, or did the turtle turn on its back to better protect itself? The turtle could not have been turned over by accident as the ground was perfectly flat."

Mr. Whelpley also states that the Box Turtles are traveling toward water at the present time (July 26). The food of the Box Turtle consists largely of vegetable matter and berries, although the larvae of insects are eaten as well as earthworms and slugs. Fat specimens are unable to close both lobes of the plastron simultaneously—the pressure of one-half of the lower shell upon the fleshy part forces open the other.

99. TERRAPENE KINOSTERNOIDES Gray. Three-toed Box Turtle.

Emys kinosternoides, Emys cinosternoides, Cistudo triunguis, Cistudo carolina var. triunguis, Cistudo clausa var. triunguis, Cistudo carolina var. cinosternoides, Terrapene triunguis.

Description.—Shell as in the preceding species. Hook of upper jaw notched, bicuspid. No trace of web between the digits. Only three clawed functional digits on the hind limb.

The zygomatic arch is more incomplete, the quadrato-jugal is reduced to a very small remnant, which has the shape of a triangle. The number of phalanges on hind foot is 2-3-3-2-1. (Baur.)

Color.—The carapace of odd specimens is yellowish (clay color).

The plastron is yellowish also. Half grown specimens very often are marked like or similar to the Carolina Box Turtle.

Size.—Length of carapace 131 mm.; width of same 100 mm.; depth 65 mm. Length of plastron 129 mm.

Habitat.—Georgia and Florida westward to the Rio Grande, up the Mississippi Valley into the State of Missouri. Missouri localities:—St. Louis, Jefferson, Washington, St. François, Shannon, Butler, Ozark, Stone, Jackson, Johnson, Pettis, Marion, Crawford, Franklin, Montgomery, Warren, and Lewis Counties.

Habits.—The Three-Toed Box Turtle has the same habits as the Common Carolina Box Turtle. It is usually found in shady valleys not far from water. The egg is ellipsoidal, the major axis being 35 mm. long and the minor 23 mm.

100. TERRAPENE ORNATA Agassiz. Painted Box Turtle.

Cistudo ornata.

Description.—Carapace short, rather depressed, the outer vertebral region flat, without any keel even in the young. Plastron not closing completely the shell, connected with the carapace by a short but distinct bridge. Hook of upper jaw notched. Digits without distinct webs. Four claws on hind feet.

The zygomatic arch has completely disappeared, only a small piece of the jugal is left. Phalanges on hind foot 2-3-3-3-1. (Baur.)

Color.—The carapace is of an olive brown to black ground color, marked with many spots and streaks of bright yellow. These yellow markings usually seem to radiate from a center from which each scute begins to grow. A broad interrupted yellow line over the middle of the back. The plastron is brightly colored, being yellow but so thickly suffused with brown, that it presents an intricate network of yellow and brown bands. The head is dark with large orange colored spots on the sides and on the top of the head, while the neck is banded with the same bright color. The scales of the fore limbs are bright red or orange.

Size.—Length of carapace 101 mm.; width of same 87 mm.; height 51 mm. Length of plastron 102 mm. I have two young specimens with egg tooth, the carapace of which is 30 mm. long and 24 mm. wide.

Habitat.—From the Rocky Mountains to Indiana, southward into Mexico. In Southern States the species

does not range eastward to Texas. Missouri localities:—St. Louis, Iron, Jasper, Johnson, Randolph, Warren, Pettis, and Montgomery Counties. In Illinois, Baldwin, Randolph Co., and Addieville, Washington Co.

Habits.—I myself have only found one specimen of this turtle in a hole occupied by a *Rana areolata.* Mr. Edgar M. Parker, an enterprising naturalist of Montgomery City, Mo., surprised me with a full set of this species which he had collected on the prairies near Montgomery.

Suborder CHILOTAE.

This suborder consists of only one family, the Soft-shelled or Leather Turtles.

Family TRIONYCHIDAE.

Turtles covered with a soft, leathery skin; lips fleshy; nostrils at the end of a flexible proboscis; toes webbed, with three claws. (Stejneger.)

Genus AMYDA.

Head slender, covered with soft skin. Head and neck completely retractile. Nostril opening at the end of a fleshy proboscis. Horny coverings of jaws concealed at the sides of the fleshy lips. Body flattened, shell covered with a continuous skin, generally cartilaginous at the margins. Digits 5-5, with large webs; first three with claws, the fourth and fifth clawless and concealed in the webs. Aquatic.

So far I have found only two species in the State, differentiated as follows:—

Nostril circular, having no papillae projecting into it from the septum. *mutica.*

Nostril crescent-shaped, having a papilla projecting into it from the septum. *spinifera.*

101. AMYDA MUTICA LESUEUR. Leather Turtle. Soft-shelled Turtle.

Trionyx muticus, Gymnopus muticus, Callinia microcephala.

Description.—Head long, low and pointed in front, descending rapidly in front of the eyes, the margins of the upper and lower jaws being concave outwardly. The horny upper jaw with a cutting edge, which

is deepest forward and bluntly toothed posteriorly. Lower jaw also with a sharp edge and both jaws furnished with an alveolar surface, the leathery snout ending obliquely, so that the nostrils are somewhat under the tip. The nostrils are circular, there being no papilla projecting into them from the septum.

Body is oval and flat. No trace of a keel along the middle of the back; often a depression instead. No spines along the anterior border of the carapace, nor any tubercles anywhere. Callosities well developed on the plastron of the adults, especially of the males. (Hay.)

Color.—Adults brown above, whitish below. Back irregularly blotched with darker brown. Head with a white stripe, margined with black from the eye over the ear and descending on the neck, head and neck below the level of the edge of upper lip white, without mottling. Under side of the feet white or bluish-gray, never mottled, a yellowish border around the edge of the carapace. In the young the lateral and posterior margin of the carapace is banded with yellow, bordered internally with black, and inside of that sprinkled with small brownish dots.

Size.—Length of carapace 356 mm.; width of same 305 mm.; depth 55 mm. Length of plastron 254 mm.

Habitat.—Central and northern tributaries of the Mississippi River and tributaries of the St. Lawrence. Missouri localities:—Mississippi, Osage, Gasconade, and Meramec Rivers.

Habits.—Ditmars in his Reptile Book gives the following life history of this turtle:—"Old logs, protruding a moist and slimy surface a few inches from the water, sometimes tempt these creatures from the element for which they are specially provided. In such situations they lie taking a sun-bath, with limbs withdrawn beneath their flabby "shells" and their long necks stretched to the fullest extent, imparting the idea of as many snakes, emerging from under flat stones. At the least alarm they scramble frantically for the water, but upon reaching it their clumsy movements are instantly transformed. Against the resisting surface, the broad, fin-like feet take great purchase and the frightened reptiles disappear with almost the agility of a scurrying school of fishes."

"The soft-shelled turtle at bay is one of the most vicious of cold-blooded creatures. Moreover, the knife-like edges of the jaws of large individuals are formidable weapons,

capable of badly lacerating a man's fingers, or possibly severing a finger if seized at the joint. The soft-shell turtle darts at the offending object with the rapidity of the serpent's stroke. It frequently takes the hooks of the fishermen and in its frenzy to escape is always an object to prompt cautious manipulation."

The food of the Soft-Shelled Turtle consists of fish, frogs, fresh-water mollusks, which are devoured in large quantities. At the end of May up to the middle of June they come out on the sandbars in the Mississippi River to deposit their eggs. I have found as many as twenty-one in one burrow. The eggs are spherical in form and about 20 mm. in diameter.

102. AMYDA SPINIFERA Lesueur. Spiny Soft-shelled Turtle.

Trionyx ferox, Gymnopus spiniferus, Trionyx argus, Aspidonectes spinifer, Trionyx spiniferus, Callinia spinifera, Trionyx spinifer.

Description.—Head small, pointed. Proboscis with the nostrils at the tip. These are crescentic in shape, a papilla projecting into each from the septum. The horny covering of the jaws concealed at the sides by the fleshy lips. Carapace with a low obtuse keel along the middle. A series of spines on the front edge of the carapace, largest in the females. Whole upper surface of shell often covered with small asperities, which are often arranged on the posterior part in longitudinal rows. Legs strong, anterior pair with several transverse scales above, posterior with a single large scale. Feet with marginal and interdigital webs. Digits 5-5. The first three on each foot with claws, the remaining two on each foot without claws and concealed by the web. Tail of male projecting considerably beyond the carapace. Callosities of plastron well developed on the middle and hinder part.

Color.—Carapace olive brown, blotched irregularly with darker brown in older specimens. In others the whole top of the carapace is marked with round, pale margined spots, those nearest the middle the largest. The margin at the sides and behind yellowish, bounded with a black line. A pale stripe, edged with black, extends from the top of the snout to the eye and behind the latter continues backward and downward to the side of the neck. A similar stripe extends backwards from each angle of the mouth. Superior surface of the neck with small blackish spots. Inferior surface of the same spotted and reticulated with black. Legs above and feet above and below, as also the tail, marked with black spots and streaks. Young examples sometimes show a line of

blackish specks on the underside of the plastron, extending from the anterior legs to the outside of the posterior pair.

Size.—Length of carapace 350 mm.; width of same 280 mm. Length of plastron 254 mm.

Habitat.—Abundant in the Central States. It inhabits the tributaries of the Mississippi River in the States of Wisconsin, Indiana, Illinois, Missouri, Iowa, Ohio, Pennsylvania, and western New York. It also occurs in the tributaries of the St. Lawrence River, the lakes of northern New York, and Lake Champlain. Missouri localities: —Mississippi, Missouri, Osage, Gasconade, Meramec, and White Rivers.

Habits.—The Spiny Soft Shell Turtles have habits similar to those of the preceding species.

List of Amphibians and Reptiles so far Found in the State of Missouri.

AMPHIBIA.

CAUDATA. Salamanders.

1. *Necturus maculosus* Rafinesque. Water Dog. Mud Puppy.
2. *Siren lacertina* Linn. Siren. Mud Eel. Two-legged Eel.
3. *Amphiuma means* Linn. Congo Eel. Congo Snake.
4. *Cryptobranchus alleghaniensis* Daudin. Hellbender. Mud Devil.
5. *Ambystoma microstomum* Cope. Small-mouthed Salamander.
6. *Ambystoma tigrinum* Green. Tiger Salamander.
7. *Ambystoma punctatum* Linn. Spotted Salamander.
8. *Ambystoma opacum* Gravenhorst. Marbled Salamander.
9. *Hemidactylium scutatum* Schlegel. Scaly or Four-toed Salamander.
10. *Plethodon erythronotus* Green. Red-backed Salamander.
11. *Plethodon glutinosus* Green. Slimy Salamander.
12. *Spelerpes longicaudus* Green. Long-tailed or Cave Salamander.
13. *Spelerpes maculicaudus* Cope. Spotted-tail or Hoosier Salamander.
14. *Spelerpes stejnegeri* Eigenmann. Stejneger's Cave Salamander.
15. *Spelerpes guttolineatus* Holbrook. Holbrook's Salamander.

16. *Spelerpes melanopleurus* Cope.
17. *Spelerpes multiplicatus* Cope. Many-ribbed Salamander.
18. *Typhlotriton spelaeus* Stejneger. Veil-eyed or Blind Salamander.
19. *Diemyctylus viridescens* Rafinesque. Newt. Red Eft. Spotted or Green Triton.

SALIENTIA. Toads and Frogs.

20. *Bufo lentiginosus americanus* LeConte. American Toad.
21. *Acris gryllus* LeConte. Cricket Frog. Savannah Cricket.
22. *Chorophilus triseriatus* Wied. Three-striped Tree Frog.
23. *Hyla carolinensis* Pennant. Carolina or Green Tree Frog. Bell Frog.
24. *Hyla pickeringii* Storer. Pickering's or Peeping Frog. Spring Peeper.
25. *Hyla squirella* Bosc. Squirrel Frog. Southern Tree Frog.
26. *Hyla versicolor* LeConte. Common or Chamaeleon Tree Frog.
27. *Scaphiopus holbrookii* Harlan. Hermit Toad. Holbrook's Spade Foot.
28. *Rana pipiens* Schreber. Leopard or Common Frog.
29. *Rana areolata* Baird and Girard. Gopher Frog.
30. *Rana palustris* LeConte. Spring or Swamp Frog. Pickerel Frog.
31. *Rana clamitans* Latreille. Green Frog.
32. *Rana catesbiana* Shaw. Bull Frog.
33. *Rana cantabrigensis* Baird. Cambridge Frog.
34. *Rana sylvatica* LeConte. Wood Frog.
35. *Engystoma carolinense* Holbrook. Carolina or Nebulous Toad.

REPTILIA.

SQUAMATA.

SAURIA. Lizards.

36. *Crotaphytus collaris* Say. Bull or Collared Lizard. Mountain Boomer.
37. *Sceloporus undulatus* Bosc. Fence Lizard. Alligator Lizard.
38. *Phrynosoma cornuta* Harlan. Horned Toad or Lizard.
39. *Ophisaurus ventralis* Linn. Glass Snake. Joint Snake.
40. *Cnemidophorus sexlineatus* Linn. Six-lined Lizard. Swift.
41. *Eumeces quinquelineatus* Linn. Blue-tailed or Red-headed Lizard. Scorpion.
42. *Eumeces anthracinus* Baird. Coal Skink.
43. *Leiolopisma laterale* Say. Ground Lizard.

SERPENTES. Snakes.

44. *Natrix cyclopium* Dumeril and Bibron. Cyclops or Green Water Snake.
45. *Natrix rhombifera* Hallowell. Diamond-backed Water Snake. Holbrook's Water Snake.
46. *Natrix fasciata* Linn. Banded or Southern Water Snake. Moccasin.
47. *Natrix fasciata erythrogaster* Shaw. Red-bellied Water Snake.
48. *Natrix sipedon* Linn. Common Water Snake. Water Moccasin.
49. *Natrix sipedon transversus* Hallowell. Woodhouse's Water Snake.
50. *Natrix grahamii* Baird and Girard. Graham's Water Snake.
51. *Thamnophis proxima faireyi* Baird and Girard. Fairey's Ribbon Snake.
52. *Thamnophis radix* Baird and Girard. Prairie or Racine Garter Snake.
53. *Thamnophis sirtalis* Linn. Common Garter Snake. Striped Snake.
54. *Storeria dekayi* Holbrook. DeKay's Snake. DeKay's Brown Snake.
55. *Storeria occipitomaculata* Storer. Storer's Snake. Red-bellied Snake.
56. *Tropidoclonium lineatum* Hallowell. Lined Snake.
57. *Haldea striatula* Linn. Little Brown Snake.
58. *Bascanion constrictor* Linn. Blue Racer. Black Snake.
59. *Bascanion constrictor flaviventris* Say. Yellow-bellied Racer.
60. *Bascanion flagellum* Shaw. Coach Whip Snake.
61. *Pituophis sayi* Schlegel. Bull Snake. Pine Snake. Western Bull Snake.
62. *Heterodon platyrhinos* Latreille. Blowing Adder. Spread Head. Spreading Viper.
63. *Elaphe vulpinus* Baird and Girard. Fox Snake.
64. *Elaphe guttatus* Linn. Spotted Coluber. Spotted Racer. Corn Snake. Red Chicken Snake. Mouse Snake.
65. *Elaphe obsoletus* Say. Black Snake. Pilot Snake. Mountain Black Snake. Rat Snake.
66. *Elaphe confinis* Baird and Girard. Spotted Chicken Snake. Gray Coluber. Gray Rat Snake.
67. *Elaphe spiloides* Dumeril and Bibron.
68. *Elaphe emoryi* Baird and Girard. Emory's Snake.
69. *Lampropeltis doliatus* Linn. Milk Snake. House Snake. King Snake.

70. *Lampropeltis getulus holbrooki* Stejneger. Salt and Pepper Snake. King Snake.
71. *Lampropeltis calligaster* Harlan. Evans' King Snake. Yellow-bellied Snake. Brown King Snake.
72. *Diadophis regalis arnyi* Kennicott. Ring-necked Snake.
73. *Liopeltis vernalis* Harlan. Grass Snake. Green Snake.
74. *Opheodrys aestivus* Linn. Rough-scaled Green Snake. Green Bush Snake.
75. *Virginia elegans* Kennicott. Virginia's Snake.
76. *Farancia abacura* Holbrook. Hoop Snake. Horn Snake. Sting Snake.
77. *Carphophis amoenus* Say. Worm Snake. Ground Snake.
78. *Tantilla gracilis* Baird and Girard. Graceful Tantilla.
79. *Elaps fulvius* Linn. Coral Snake. Bead Snake. Harlequin Snake.
80. *Agkistrodon piscivorus* LaCépède. Water Moccasin. Cotton Mouth.
81. *Agkistrodon contortrix* Linn. Copperhead. Moccasin.
82. *Sistrurus catenatus* Rafinesque. Prairie Rattlesnake. Massasauga.
83. *Sistrurus miliarius* Linn. Ground Rattlesnake. Pigmy Rattlesnake.
84. *Crotalus horridus* Linn. Timber Rattlesnake. Banded or Northern Rattlesnake.

TESTUDINATA. Turtles.

85. *Chelydra serpentina* Linn. Common Snapping Turtle.
86. *Macrochelys lacertina* Schweigger. Alligator Snapping Turtle.
87. *Aromochelys odorata* Latreille. Musk Turtle. Stink Turtle.
88. *Aromochelys tristycha* Agassiz. Southern Musk Turtle.
89. *Kinosternon louisianae* Baur. Louisiana Mud Turtle.
90. *Chrysemys treleasei* Hurter. Trelease's Turtle.
91. *Chrysemys belli* Gray. Bell's Turtle.
92. *Chrysemys dorsalis* Agassiz.
93. *Pseudemys elegans* Wied. Elegant Turtle.
94. *Pseudemys troostii* Holbrook. Troost's Turtle.
95. *Pseudemys texana* Baur. Texas Turtle.
96. *Malaclemys lesueuri* Gray. Map Turtle. Saw-back Turtle.
97. *Malaclemys geographica* LeSueur. Map Turtle. Geographic Terrapin.
98. *Terrapene carolina* Linn. Carolina Box Turtle.
99. *Terrapene kinosternoides* Gray. Three-toed Box Turtle.

100. *Terrapene ornata* Agassiz. Painted Box Turtle.
101. *Amyda mutica* LeSueur. Leather Turtle. Soft-shelled Turtle.
102. *Amyda spinifera* LeSueur. Spiny Soft-shelled Turtle.

SUMMARY.

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		102 species.

GLOSSARY.

Allantois.—A membranous appendage of the embryos of mammals, birds, and reptiles,—in mammals serving to connect the fetus with the parent; the urinary vesicle.

Alveolar surface.—A flat masticatory surface of the jaws of turtles seen just within the cutting edge.

Amnion.—A thin membrane surrounding the embryos of mammals, birds, and reptiles.

Amphicoelous.—Said of those vertebrae that are concave at both ends.

Anal plate.—The large scale immediately in front of the vent of serpents.

Anamniote.—Applied to fishes and amphibia in which there is no amnion and allantois. (Embryology.)

Ankylosed.—Firmly united, as when bones are grown together.

Anteorbital.—A small epidermal plate of the head of snakes, which lies immediately in front of the eye. If there are but three plates between the eye and the nostril, either the anteorbital or the loral is missing. If the plate present next the eye has its greatest length horizontal, it is the loral; otherwise it is the anteorbital.

Axilla.—The arm-pit.

Azygous.—A plate directly behind the rostral, placed in the middle line and, therefore, single.

Barbels.—A short worm-like process of skin about the mouth or at the chin.

Branchiae.—Gills, as the respiratory organs of fishes, etc.

Branchial arches.—Bony or cartilaginous arches that support the gills of fishes, or arches that correspond to these in other animals.

Bridge.—That portion of the shell of a turtle which joins the carapace to the plastron.

Callosity.—A patch of hard skin on the plastron of soft shelled turtles.

Canthus rostralis.—A slight ridge from the eye to the tip of the snout, separating the upper surface of the head from the side.

Carapace.—The upper portion of the shell of turtles.

Carinated.—Furnished with a keel or sharp ridge lengthwise.

Carpus.—The wrist bones connecting the fore-arm with the long bones of the hand.

Choanae.—The internal nasals.

Clavicle.—A bone corresponding to the human collar bone.

Cloaca.—The common chamber into which the intestines, the ureters and the genital ducts open.

Condyle.—Articulating surface of a bone.

Coracoid.—A bone or cartilage on the ventral side of an animal, which helps to form the socket for the articulation of the arm.

Costal.—Pertaining to the ribs. The costal furrows, or grooves, of the Caudata that run across the body between the fore and hind legs.

Crown shields.—The large plates which cover the upper surface of snakes' heads.

Dentaries.—The anterior bone of the lower jaw, the one usually bearing the teeth.

Dermal folds.—The thickened ridges of skin on the back of some frogs; the glandular folds.

Diapophysis.—The transverse process of a vertebra; here used of that of the sacral vertebra.

Digits.—Fingers and toes.

Distal.—Remote from point of attachment.

Entoplastron.—One of the bones of the plastron of a turtle.

Emarginate.—Furnished with an obtuse notch.

Epicoracoid.—The portion of the coracoid bone or cartilage lying in front of and more or less separated from the rest by a fontanelle.

Femoral.—Pertaining to the thigh. Femoral pores are found on the under side of the thighs of some lizards.

Fontanelle.—A space filled with membrane between bones that approach one another without meeting.

Fossa.—A depression or excavation more or less cup-shaped.

Frontals.—Plates of the top of the head of a snake.

Gastrosteges.—Transverse band-like plates on abdomen of snakes. Ventrals.

Gular.—Pertaining to the throat; gular-fold, a fold of skin across the throat.

Holders.—Organs of adhesion at the corners of the mouth of a tadpole.

Humerals.—Scutes of the plastron of a turtle.

Hypapophysis.—A process from the median line of the under surface of the bodies of the vertebra.

Imbricate.—Overlapping like shingles.

Inframarginals.—Scutes of some tortoises lying above the marginals.

Inguinal.—Pertaining to the groin.

Internasals.—Plates on top of snout, behind the rostral and between the nasals in serpents.

Isodont.—Equal toothed.

Keel.—A ridge. Keeled, furnished with a sharp ridge.

Labials.—Plates that border the mouth, except the rostral. In serpents.

Larva.—The undeveloped young of some animals, as the tadpole of frogs.

Loral.—Pertaining to the space in front of the eye. See anteorbital. Serpents.

Mandible.—The lower jaw.

Marginals.—The plates around the carapace. Turtles.

Maxillary bones.—Those bones of the upper jaw lying behind the premaxillary of each side usually bearing the outermost row of teeth.

Metacarpals.—The long bones in the hand separating the carpals from the phalanges.

Metatarsals.—Bones in the foot separating the tarsals from the phalanges.

Nares.—Openings of the nose; external and internal.

Nasal plates.—Plates about the external nares. Serpents.

Nuchal.—Pertaining to nape of neck. Turtles.

Occipital.—Belonging to the hinder part of the head. Occipital plate in serpents.

Ocellated.—Furnished with eye-like spots, spots consisting of concentric rings.

Opisthocoelous.—Said of vertebrae which are concave at the hinder end and convex at the anterior end.

Oviparous.—Producing young from eggs that hatch after deposition.

Ovoviviparous.—Producing young from eggs which hatch before being laid.

Palatine.—A bone of the roof of the mouth lying behind the vomer.

Palmate.—Webbed.

Papillose.—Covered with papillae or small fleshy projections.

Parasphenoid.—A broad bone underlying the brain case. Pharasphenoidal teeth are found in the hinder part of the roof of the mouth.

Paratoid.—A projecting gland behind the jaw on the side of the neck. Paratoid glands of toads are elevated glandular bodies at the sides of the back part of the head.

Pectoral arch.—The bones that support the fore limbs, as the clavicle, coracoid and scapula.

Pedicillate.—With a stem, stalk, or foot, like a mushroom.

Penultimate.—Next to the last.

Pineal eye.—A minute whitish, transluscent spot showing through the interparietal or occipital plates on the head of some lizards.

Plantar tubercles.—Tubercles on the soles of the feet.

Plastron.—The lower portion of the shell of a turtle.

Pleurodont.—With the teeth grown fast to the inner side of the bone of the jaw.

Plicae.—Folds or grooves.

Prefrontals.—In front of the frontal in serpents.

Premaxillary.—The bones forming the anterior border of the upper jaw, meeting in median line.

Procoelous.—Said of vertebrae which have the anterior end concave, the posterior convex.

Proximal.—Nearest.

Pterygoid.—A bone of the roof of the mouth lying on each side immediately behind the palatine.

Quadrate.—The bone on each side of which the lower jaw of batrachians and reptiles is swung.

Rostral.—The epidermal plate covering the snout of snakes and lizards.

Rugosities.—Roughnesses or wrinkles.

Scuta.—A large epidermal scale.

Semipalmate.—Toes half-webbed.

Septum.—A dividing wall, as that between the nasal passages.

Serrated.—With saw-tooth projections.

Sessile.—Attached without any stalk or foot.

Snout.—The portion of the head in front of the eyes.
Squamosal.—A bone usually overlying the inner ear; in snakes attached to the hinder portion of the skull and supporting the quadrate.
Subcaudals.—The large scales on the under side of the tail of a snake.
Subcircular.—Nearly round.
Subgular.—On the throat or under side of the neck.
Suborbitals.—The plates between the eye and the labials.
Superciliary.—The plates over the eye of a snake.
Symphysis.—Junctures of bones, especially along the median line.
Tarsal bones.—Bones in the ankle between the long bones of the foot and leg.
Temporal arch.—A bony bar from the upper jaw to the quadrate, overlying the temporal muscle, found in some tortoises.
Temporal plates.—Between the occipitals and labials.
Tympanum.—The drum-head of the ear.
Urostyle.—The rod-like posterior termination of the spinal column of frogs.
Vent.—The opening outwardly of the cloaca.
Ventrals.—The epidermal plates on the belly of snakes. Gastrosteges.
Vertebra.—One of the bones of the back.
Vertical plate.—In the center of the top of the head between the eyes. Frontal plate.
Vitta.—A stripe.
Vomer.—A bone lying in the roof of the mouth just behind the premaxillary, one on each side, in amphibia and reptilia.
Vomero-palatine.—The united vomer and palatine.
Xiphisternum.—The posterior segment of the sternum.
Zygomatic arch.—Temporal arch of bones in turtles.

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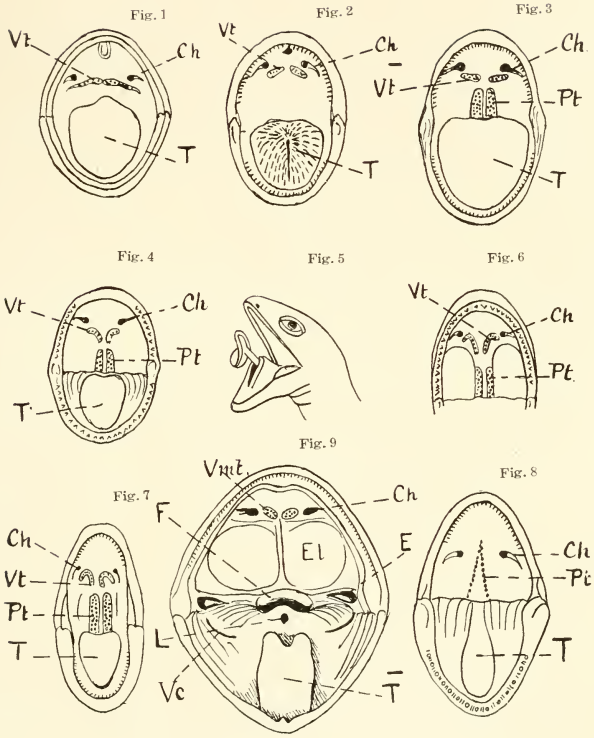


MOUTH CONSTRUCTION OF SALAMANDERS AND FROGS.

Fig. 1

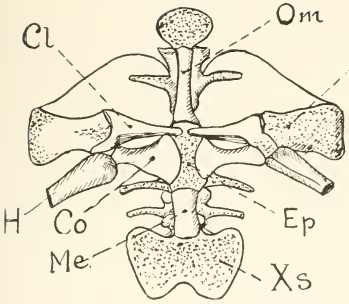
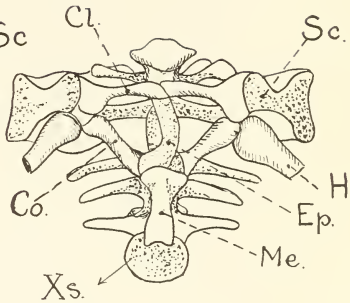


Fig. 2



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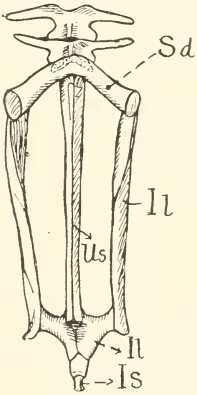
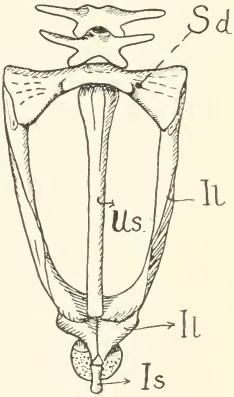
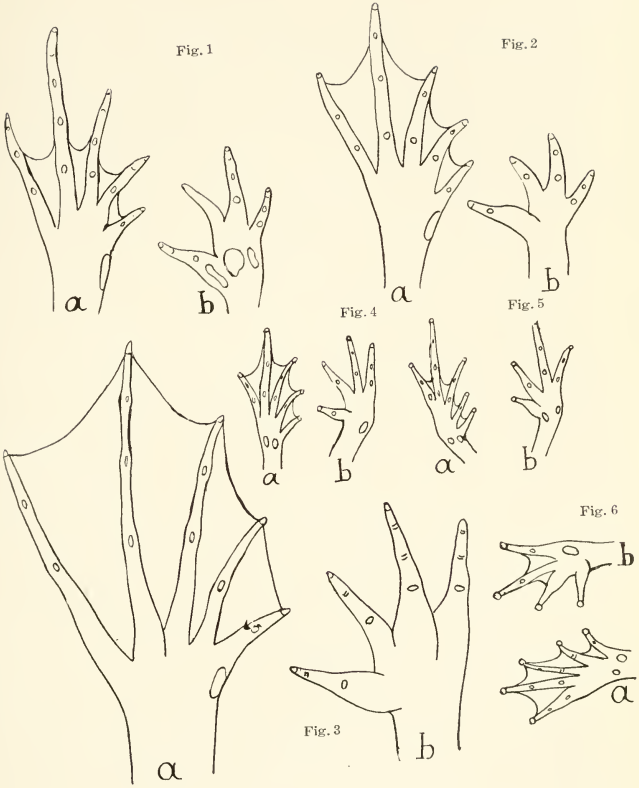


Fig. 4



SHOULDER AND PELVIC GIRDLES OF FROGS.



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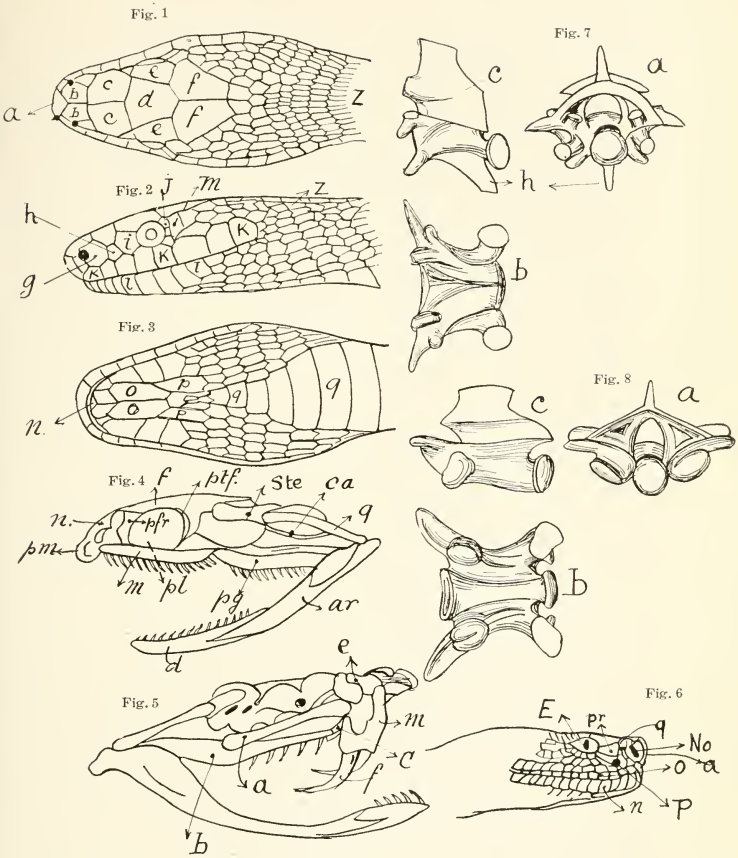
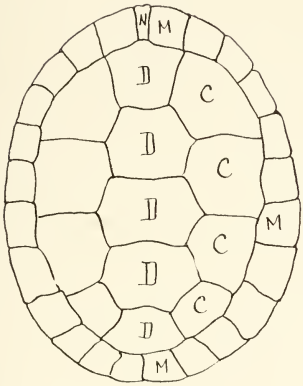


HEADS OF SNAKES.

Fig. 1



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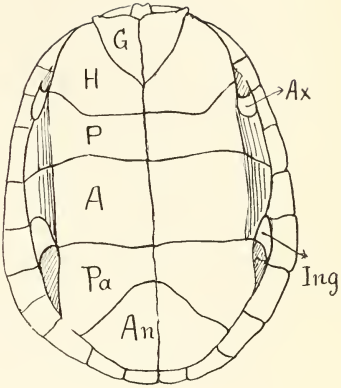

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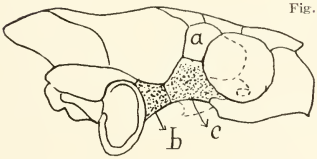

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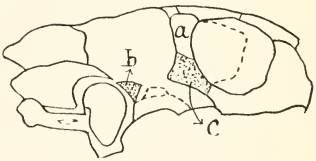

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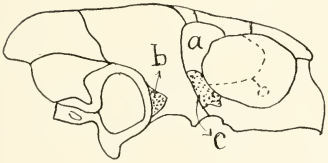

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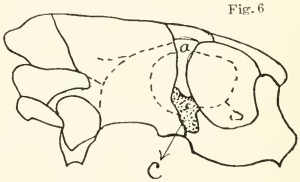
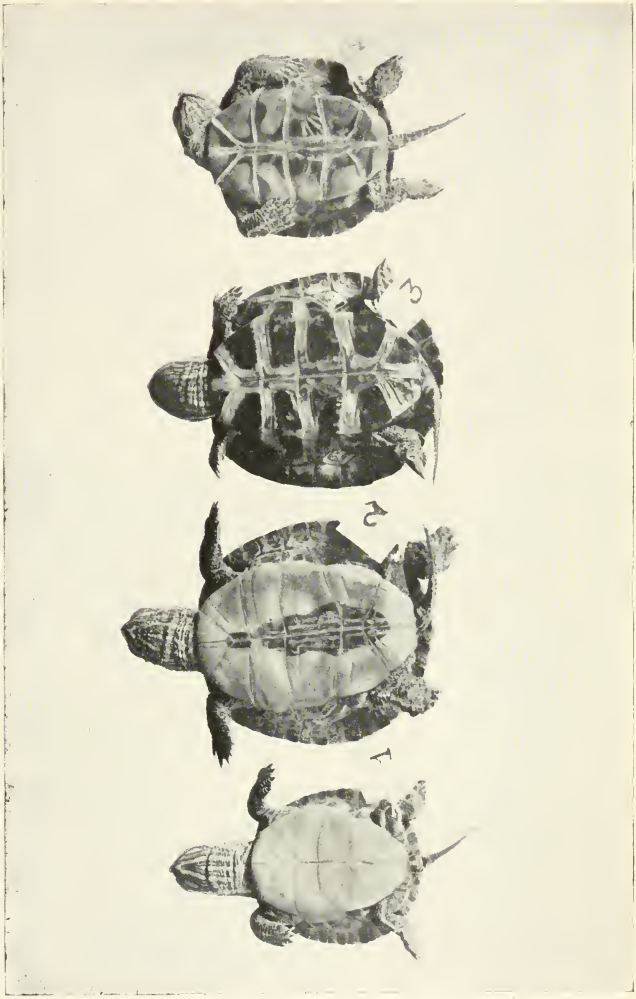
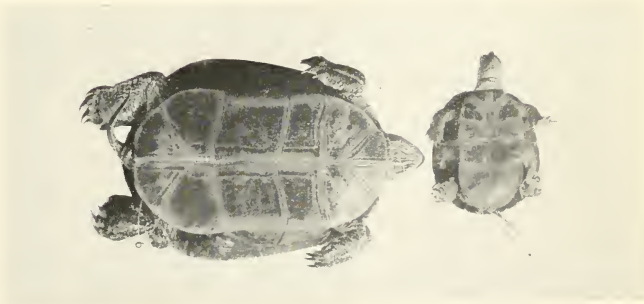


SHELLS AND SKULLS OF TURTLES.



YOUNG CHRYSEMYS.



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VOL. XX. No. 6.

SEXUAL SELECTION EXPERIMENTS IN THE CECROPIA MOTH.

FURTHER OBSERVATIONS ON COPULATION AND OVIPOSITION IN SAMIA CECROPIA LINN.

PHIL RAU.

Issued August 9, 1911.

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Continued on page 3 of Cover.

SEXUAL SELECTION EXPERIMENTS IN THE CECROPIA MOTH.*

PHIL RAU.

INTRODUCTION.

This paper gives an account of an experimental search for the factors at work in determining the choice of mates in *Samia cecropia* Linn.

While there has been much contention in the field of Sexual Selection, it has been based too largely upon theory. The present paper is not an attempt to prove or disprove any theory extant, but merely to pick up the simple facts which living material offers us.

The seventy-three experiments were divided among several problems as follows:

Given the opportunity of choice:

1. Do the males mate with the younger or older females?
2. Do the females mate with the younger or older males?
3. Do the males mate with the beautiful or the unattractive and dilapidated females?
4. Do the females mate with the beautiful or the unattractive and dilapidated males?
5. Do the females mate with the wingless or normal males?
6. Is the female capable of mating when both antennae are removed?
7. Is the male capable of mating when:
   (a) one-half of each antenna is removed;
   (b) all of either antenna is removed;
   (c) both antennae are removed?

*Read before the Entomological Section, April 27, 1911, and presented by title to The Academy of Science of St. Louis, April 3, 1911.

It was not always possible to devote as many experiments as desired to some particular problem, because the supply or the characteristics of the material then at hand would not permit.

The insects usually left the cocoon during the afternoon; this made exact records of emergence possible. The sexes for this year were about equal in number, and their habits monogamous.[1]

The mating cages were ordinary dome-shaped wire dish-covers measuring 32 inches in circumference. Each cage contained from two to four individuals, some of which were marked with ordinary writing fluid.

After the first fifteen experiments, the work became too complex, and details on behavior could not be recorded. The notes are given essentially as they were jotted down as each experiment was in progress; the conclusions and comparative notes were added later.

The insects were all normal and unmated unless otherwise stated.

It gives me pleasure to here acknowledge my indebtedness to my wife for valuable co-operation in the preparation of the manuscript.

Experiments.

Experiment 1.—April 21, 5:00 P. M.

♀ 1. Age 7 days 20:30 hours.
♀ 2. Age 6 days 3:30 hours.
♂ 3. Age 0 days 1:30 hours.

Object.—Will the male select the older or the younger female?

Behavior.—5:00. The females immediately become active when the male is placed with them; he shows no eagerness to mate.—5:20. The male is now also actively fluttering about. The ovipositor of female 1 has been completely protruded, and in so doing, an egg dropped.—5:21. The male and female 2 have become calm, but female 1 continues to vibrate the wings nervously at the farthest side of the cage. She makes her way to the male, chasing him as it were for a short

[1] See page 310.

distance and causing him to drop to the floor.—5:40. All three insects resting quietly, female 1 laying a small number of unfertilized eggs.—12:00 Midnight. Up to this time all have remained quietly in the same position excepting at 11:30 when the male vibrated his wings actively for three minutes.—April 22, 7:00 A. M. Find the male in copulo with female 1, the older. This moth had deposited 17 eggs before mating.

Experiment 2.—April 22, 6:00 P. M.

♂ 4. Age 0 days 5:30 hours. Lacks a portion of hind left wing; left the cocoon in this condition.
♂ 5. Age 0 days 5:30 hours.
♀ 2. Age 7 days 4:30 hours.

Object.—To see whether the female will mate with the normal or deformed male when they are of equal age.

Behavior.—6:00. The female, when placed with the males, immediately begins to vibrate the wings and protrude the copulatory organ, and then flutters about unceasingly for ten minutes. During this time male 4 slowly moves the wings up and down for perhaps five minutes.—6:10. All this time male 5 has remained quietly in one position, but now advances toward the female.—6:15. The female remains quiet, while the two males flutter actively about her. The indications at this moment are that the smaller, deformed male will win.—6:20. All of the insects have settled down for the evening, the two males at equal distance from the female.—April 23, 9:00 A. M. The female found in coition with male 4.

Thus the deformed moth was victor in spite of the fact that its rival was normal and had no advantage in age.

Experiment 3.—April 25, 4:50 P. M.

♀ 1. Age 11 days 20:20 hours. Has already mated.
♂ 3. Age 4 days 1:20 hours. Has already mated.
♂ 6. Age 3 days 2:20 hours.

Object.—To ascertain whether an already mated female, if she remates at all, will select the unmated insect in preference to the mated one.

Behavior.—4:50. When the unmated male 6 is introduced, the female remains stationary, vibrating the wings rapidly. This causes a somewhat musical sound as the wings beat upon the wires of the cage. The male dashes about, throwing himself bodily against her and often falling to the floor. This unmated male and the female which has previously mated, seem extremely eager to mate.—5:00. This agitation has con-

tinued for ten minutes, and now all have settled down quietly for the evening.—April 28, 11:00 P. M. Death of female. Mating has not taken place although the insects have been together for over three days.

Thus, eager as this male and the old fertilized female were to mate, copulation did not occur. So long as mating was not sincerely sought by the female, which had by this time deposited many fertile eggs, why this coquettish display and eagerness to arouse the male? It may be that she instinctively behaved thus when brought into the presence of unmated males. We must not overlook the fact that the old age of the female may have prevented mating, but old age surely did not prevent the desire.

When we recall the prime age of the mated male, we are surprised at his unswerving indifference throughout the experiment. We cannot argue that the previous mating caused the female to lose certain attractiveness (odor, etc.), for we saw her perfectly successful in exciting the unmated male. Why the activity on the part of an old mated female and not so on the part of a young mated male?

Experiment 4.—April 25, 4:00 P. M.

♂ 5. Age 3 days 3:30 hours.
♀ 2. Age 10 days 2:30 hours. Fertilized and eggs deposited.

Object.—To find if a female which has been fertilized and has oviposited will again mate if the male be still unmated.

Behavior.—4:00. The female is unmoved when the male is introduced; male at once becomes active. As his wooing becomes too ardent, the female demurely moves to the far end of the cage and there remains indifferent. The male takes his position on the floor of the cage some six inches from her, raising the fore part of his body high up, and resting on the two hind legs and the tip of the abdomen. The four front legs are folded up close to the thorax—"clasped to his throbbing heart." In this position the wings are rapidly beaten against the floor, creating an audible hum. This balancing and "music" has continued for exactly three minutes without causing

the slightest movement on the part of the female. The male flutters about, throwing himself bodily against her four or five times, and then quietly waits.—4:30. All is quiet. The male has no doubt discovered that all attempts at attracting the female are futile.—April 28, 11:00 P. M. Death of the female. Mating has not taken place, although the pair have been together for over three days.

This shows that an old fertilized female would not mate again, even with a spirited young male.

How different was the behavior of these females, in experiments 3 and 4, the one coldly indifferent, the other wildly eager, and, strange to say, the older was the more unladylike of the two.

Experiment 5.—April 28, 11:55 P. M.

♂ 3. Age 7 days 8:25 hours. Previously mated; wings badly damaged.
♂ 6. Age 6 days 9:25 hours.
♂ 27. Age 0 days 6:05 hours.
♀ 25. Age 0 days 6:55 hours.

Object.—To see which male will be given the preference by a normal virgin female, that is, if the female does the choosing; or which of the three males will be victor in the struggle for a mate.

Behavior.—11:55. The three males immediately become active as follows: Male 3, which has previously mated and whose wings are in no condition to flutter, wabbles along the floor, frequently falling to one side. Male 6, the oldest unmated male, has fluttered wildly about the female and has been beating against the domed ceiling and the floor alternately for two minutes. The young male 27 has assumed a position on the floor of the cage and gently vibrated the wings for two or three minutes. Male 6, after resting a half minute, flutters with male 27 wildly around the female, where she clings at the top of the cage, slowly moving her wings to and fro. This commotion has lasted about two minutes, during which time the males have often knocked one another as well as the female to the floor. During all this, male 3 has remained on the floor, nervously shaking his remnants of wings and legs. All of the work so far has led to the conclusion that the insects are monogamous. Yet we see that male 3, which is pretty well on in age and has already mated, becomes sexually excited when in the presence of others in that condition. 12:00 Midnight. All

are resting quietly, the female in the center of the dome.—12:04. From 12:02 to 12:04 there has been a skirmish, all the insects fluttering and knocking one another about. The female and male 27 are now wandering about at the top, and it seems she is following this particular male, which, by the way, is the younger and unmated. The female has reached the highest point, and male 27, walking around her as he clings to the wires, has completed perhaps six circles and apparently would continue, but male 6 interrupts him by constantly fluttering in the vicinity of the female, although he was quietly resting on the floor when his rival, male 27, commenced this performance. After causing this interruption male 6 again retires to the floor, apparently much fatigued. Male 3 lies in the corner of the cage and takes no part in the courtship.—12:08. The female and male 27 are now the only ones which are still active. These two flutter wildly about each other.—12:09 All quiet.—12:11. Male 27, after taking his position directly in front of the female and fluttering his wings while clinging to the wires of the cage, has moved in this manner and completed seven or eight circles around her.—12:13. Both are now participating in this quaint performance.—12:14. She now returns his courtesy, circling about him as he hangs quietly from the wires. Males 3 and 6 have made no further attempt at courting.—12:18. The two insects are gently touching wings. They are so near to each other that their abdomens sometimes touch as they hang, back to back, from the dome.—2:00. All have been quiet since 12:30, and mating has been expected to take place at any time. Sometimes I have darkened the room for many minutes at a time, but although the two insects are less than an inch apart, they have quietly kept their places.—7:30. As the behavior has led me to expect, I find the female in coition with male 27, the youngest of the three and the one which has been most persistent in his courtship.

The very old male, as we have seen, was the first to tire, but he had already mated and the wings were in no condition for courting. Of the two unmated males, the one less than a day old proved himself better able persistently to court than the one six days old. The gradual dropping out of the game, one by one, of the older males shows to a degree that the female does little or no selecting. The behavior of male 6 shows that he lost not because he was less eager or sexually unfit, but because of his age.[2]

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[2] See foot-note, Experiment 6.

Experiment 6.—April 29, 11:10 P. M.

♀ 37. Age 0 days 9:38 hours.
♂ 30. Age 0 days 12:20 hours. Wings removed.
♂ 6. Age 7 days 8:40 hours.

Object.—To ascertain whether a virgin female will mate with a young wingless male or an old normal one. If color plays a part in selection, we should see the old perfect insect chosen; if vitality decides her choice, we should expect to see the young wingless male mate. The old, normal individual will have an equal or perhaps better chance to mate in competition with a young wingless one.

Behavior.—11:10. The female hangs quietly from the dome. Male 6, which has been passive for the last twenty hours (since he became so in Experiment 5) becomes extremely active as his cage is brought near that of the female. Male 30 rests upon the floor, while male 6 flutters wildly about the female.—11:18. This continues until the female falls, or perhaps is knocked to the floor. Here she remains, gently moving the wings, while male 30 crawls to the top. The slow movement of her wings soon evolves into wildest fluttering about the floor in company with male 6. Presently the pair creep to the top of the cage and continue their activity for one minute, and then fall to the floor. The female and wingless male 30 again reach the top of the cage, where the fluttering is extremely active on the part of the female, and as lively as could be expected of the wingless male. At intervals the male comes to a complete rest and the female circles about him, and again both hang for a half minute or so at a time, so close together that the ventral surfaces of their abdomens touch, and gently move their wings, or remnants of such. During all this the normal but aged male 6 lies quietly on the floor, making no attempt to win the female.—11:30. All are quiet; male 30 hangs from the top of the cage about five inches from the female.—1:30. Same.—Morning. The female and the young, wingless male 30 in copulo, while the older perfect male, although equally eager, has lost.[3]

Experiment 7.—April 29, 9:45 P. M.

♀ 32. Age 0 days 10:45 hours.
♂ 27. Age 1 day 3:55 hours. Left off mating 15 minutes previously.

[3] Although male 6 appeared sexually excited in all three experiments, 5, 6 and 14, the fact that he lost out in all might suggest that he was in some unknown way defective. In all of the trials he was matched against younger rivals.

Object.—To ascertain if a male which is very young and has just left off mating will again mate with a young unfertilized female.

Behavior.—9:45. When placed in one cage, both flutter about wildly for fully five minutes. Then the female clings to the wire netting at the top of the cage and, excepting for an occasional movement of the wings, remains perfectly quiet, while the male circles about her, flapping the wings wildly and often falling to the floor, but quickly scrambling again to the top where the female is stationed. Often he touches her abdomen with his legs and brushes her body with his, and sometimes he nestles along side so that the wings and bodies touch. To all of this the female is coldly indifferent. These maneuvers have continued for six minutes. At 9:51 both settle down, the male clinging to the wires two inches from the female.—1:30. All continues quiet.—Morning. The pair are found in copulo.

This shows that a male may mate the second time with a virgin female when both are comparatively young. The male which had already been in copulo showed much eagerness to mate; the female showed little or no eagerness. Perhaps the mated male had lost attraction for her, or more likely the female was incapable of sexual excitement at so early an age. In other experiments however we have seen activity in the female at the same age or even younger.

Experiment 8.—April 29, 9:30 P. M.

♀ 25. Age 1 day 4:30 hours. Already fertilized.
♂ 5. Age 7 days 9:00 hours.
♂ 31. Age 0 days 11:29 hours. Introduced at 10:24 p. m.

Object.—To ascertain if a fertilized female can be tempted into mating a second time, and, if so, which male will be preferred, the one a half day old or the one almost seven days of age.

Behavior.—10:24. Since 9:30 female 25 and male 5 have been together in the cage but neither has yet displayed any inclination to mate. Male 31 is now introduced. He immediately flutters up to the female, which is clinging to the top of the cage, quietly takes his position at some three inches distance, and makes no more ado. The old male 5, resting on the floor, now gently moves the wings for about two minutes, and then for a half minute flutters wildly about the cage. This is followed by male 31 fluttering the wings, while clinging to the

wires of the cage, and describing several circles about the female, and all again become quiet.—11:10. It has been necessary for me to be absent from them since the last observations. The female however is still hanging from the top of the cage, male 31, clinging to the wire, flutters about her in circles, and male 5 lies quietly on the floor, apparently having given up the chase. Only when male 31 flutters against him he stirs, gently moves the wings to and fro for a minute, and lapses again into quietness.—Morning. Mating has not yet occurred.—April 30, 9:30 P. M. Male 31 has been fluttering about the cage so violently for a half hour that it becomes necessary to remove him.

Thus, although the insects were left together for 24 hours, this fertilized female did not remate, even when courted by two good males, aged 7 days, and less than 1 day.

Experiment 9.—April 30, 11:55 P. M.

♂ 31. Age 1 day 13:00 hours. Large; expanse of fore-wings, 16.1 cm.; brightly colored; pubescence on abdomen bright red.

♂ 36. Age 1 day 10:25 hours. Expanse of fore-wings, 15.1 cm.; wings not so brightly colored and slightly damaged; pubescence on the entire abdomen dingy brown.

♀ 47. Age 0 days 11:35 hours.

Object.—To see whether the female will give evidence of any choice based on beauty and bright coloration in the male.

Behavior.—11:55. Male 31 remains on the floor quite inactive. Almost immediately the female and male 36 begin to chase each other, and at last she pursues him to the top of the cage. Here he behaves very sedately, while she clings to the wires near by, beating her wings and rudely striking his, and finally comes very close in front of him alluringly opening and closing her wings several times. To all of this he remains indifferent. Male 31 is now also near the female, but like male 36, he pays no attention whatever to this bold display. For seven minutes now the female has fluttered anxiously about male 36, often beating her wings against his. She alone flutters about, apparently much more eager to mate than the males. She clings at the top of the dome flapping her wings, circles about many times and goes back again and again to male 36 and beats his wings. She pays little attention to male 31 excepting that twice she has chanced to fly to him, but at once flitted back again to 36.—1:15. The insects have all been at perfect rest since 12:05.—6:30. All are found in the identical positions. 7:00. The female is now found in copulo with male 36.

In this case the male which mated was the one of dull color, small size, and damaged wings, but younger age than its rival. The persistence of the female in following him shows the exercise of choice on her part. In other of our experiments we have been unable to detect much evidence of such choice. But in this, our clearest case, her choice was quite contrary to what theories would lead us to expect. In the next experiment this fine male mated. The fact that the male proved to be perfectly good only makes her choice the more perplexing.

Experiment 10.—May 1, 7:25 P. M.

♀ 57. Age 0 days 5:55 hours. Small; expanse of fore-wings, 12.5 cm.; width of abdomen, 1.4 cm.; length of body, 3.6 cm.

♀ 54. Age 1 day 4:10 hours. Large, beautiful; expanse of fore-wings, 17.5 cm.; width of abdomen, 1.8 cm.; length of body, 4.2 cm.

♂ 31. Age 2 days 8:30 hours.

Object.—To see whether the male will exercise any choice, and if so whether the very small, or a large beautiful female will be favored.

Behavior.—7:30. For five minutes all have constantly fanned the wings gently to and fro as they cling to the side wires. Now the male crawls to the top and his movement becomes more rapid; he flutters down to where female 54 is resting and flies against her several times. She now remains motionless in spite of the rough attentions of the male. Next he comes near beside her and strikes her with his wings, then flits to the top of the cage only to return at once and resume his position so that his vibrating wings beat against hers.—7:35. The male takes his position directly in front of female 54 and there remains motionless. Meanwhile the small female 57 clings to the opposite side of the cage and fans the wings briskly for a minute and a half, then gently creeps closer and closer to the male. As she nears him, her wings flap violently; she beats her wings against his until she falls to the floor, flies away, and back at once to him. Again she flutters to the floor, passing blusteringly between the male and female 54, and twice again in precisely the same manner. It appears that by thus cutting in between them she is attempting to place distance between the male and her beautiful rival, but throughout the performance female 54 stands immovable.—7:40. The two females have settled down on either side of the male, so near that in occasionally moving their wings they often brush his. From the behavior of the

male it is easy to see that the larger female 54 is the more attractive to him. The smaller female seems to exert every effort to attract his attention.—7:43. Judging from previous experiments we would expect all three insects to remain perfectly quiet until mating takes place, but now we see female 57 giving an occasional, abrupt, hard blow with her wings against the wing of the male, causing him each time to respond in a similar manner.—7:45. We see this female slyly moving so close to the male as to gently touch the ventral portion of his abdomen with her wings as they hang. The male each time puts out one of his fore-legs and touches the wing as it comes toward him, but whether to resist this caressing or to encourage it cannot be determined.—8:00. This behavior has continued up to the present, and now all are at rest, the two females at about equal distances from the male. The ovipositor of female 54 is exposed. All the indications are that the large moth will soon mate.—May 2, 8:00 A. M. The male is now found in copulo with female 57, the smaller and less beautiful insect. Was she chosen because she was about a day younger, or because of her persistent obtrusiveness?[4]

Experiment 11.—May 1, 8:30 P. M.

♂ 62. Age 0 days 4:40 hours. Very small; the two left wings badly deformed; length of body, 2.8 cm.; width of abdomen, 0.8 cm.; expanse of fore-wings, 11.5 cm.

♂ 17. Age 3 days 7:35 hours. Length of body, 3.8 cm.; width of body, 1.1 cm.; expanse of forewings, 15 cm.

♀ 56. Age 1 day 1:30 hours.

Object.—Will a small, deformed, young male be preferred to a large, well-formed male 3 days older?

Behavior.—8:30. The female remains calmly clinging to the wires when the males are admitted. After a few seconds' rest, male 17 flutters against her, roughly knocking her to the floor. Again and again she attempts to remount, but each time is beaten back. Sometimes she is successful in reaching the top, but often she is thrown down before reaching half way. Since the first few falls of the female, male 62 has taken his position at the top of the cage. I wonder if this young male may be the attraction which leads the female repeatedly to try to reach the top. Perhaps this is also why male 17 continually hinders her progress. Eight times the female has attempted to mount to the top, and each time male 17 has fought her back. At last however she has gained the dome and has quietly taken up her position about an inch and a half from male 62. They both gently move their wings to and fro. Their positions are such (suspended by the fore-legs) that every time she closes her wings she entirely covers the wings and body of

[4] Anyone observing a few unmated Cecropias together at night will be at once convinced that this behavior is far from accidental.

the male, thereby gently stroking his wings and lateral parts of the abdomen. Once more male 17 knocks the female to the floor, and as she again starts for the top he defiantly takes his position just ahead of her. Her persistence is stubborn, but his hindrance at last stops her progress. After a few seconds male 62 drops beside the female, whereupon male 17 flies up to the top and apparently awaits the female. Male 62 and the female together have climbed part way up and are clinging to the side wires, when male 17 comes down and flutters wildly about the female with great commotion. At last, after so much exertion, he has won her recognition, and we now see the pair flitting merrily about each other for just a minute and a half. Meanwhile male 62 betakes himself again to the dome, and in a short time after her merry frolic we see the female slowly making her way back to him. As she draws nearer and nearer to the jealously coveted place, the fluttering on the part of male 17 becomes more and more violent, until again he succeeds in beating her to the floor; he promptly joins her there and they resume their merry whirls. But the female heeds him for only one-half minute, and then turns back to her first choice. It is now 8:37 P. M. The female comes directly in front of male 62, and closing her wings on either side of him (both hang free) almost hides him from view. In this position she violently flaps her wings, and as they close over the male they strike the lateral portions of his body and the under sides of his wings. He is motionless and unresisting. And now while male 17 quietly remains below, these two playfully wheel about each other in alternating circles. At 8:42 all become quiet, the chosen pair at the top, and male 17 hanging a short distance away. May 2, 8:00 A. M. The female in copulo with male 62.

Throughout the experiment it was clearly evident that her preference was for the dilapidated male, which was the younger, but it seemed that the eagerness and strength of male 17 might prevent the mating.

Experiment 12.—May 1, 8:40 P. M.

♂ 59. Age 0 day 5:00 hours.

♂ 61. Age 0 day 4:50 hours. A beautiful insect; the usual dark rings of pubescence on the abdomen are bright red; one antenna somewhat deformed and right fore-leg missing.

♀ 67. Age 0 day 2:35 hours.

Object.—To see, when both males are of almost the same age, whether a slightly deformed one of abnormally bright color will mate in preference to a perfect insect of only normal color.

Behavior.—8:40. When placed together male 61 gently moves the wings, male 59 rests quietly while the female moves to male 61 and both hang from the top. Male 59 slowly moves behind the female, and now all three form a single file, the female in the center. They make a handsome showing all in a row, majestically waving the wings. After a few seconds male 59 in the rear, crowds in front of the female between her and his rival, whereupon the latter drops to the floor. The wings of the female are still moist; this prevents active movements. Male 61 has crept part way up the side of the cage, and all remain quiet. No insect in the cage shows any eagerness to mate. We little wonder at this when we remember that none is over 5 hours old.—May 2, Midnight. They have been watched all day, with no evidence of mating.—May 3, 8:00 A. M. Not yet mated.—8:47. Mating has at last taken place with male 61, the brightly colored insect with crippled antenna and one fore-leg lacking. This one, incidentally, is slightly younger.

Experiment 13.—May 1, 9:20 P. M.

♂ 58. Age 0 days 5:40 hours. Wings removed.
♂ 41. Age 2 days 5:50 hours.
♀ 60. Age 0 days 5:35 hours.

Object.—In Experiment 6 the difference in the age of the males was too great. In this experiment we shall find whether the female prefers a normal insect, 2 days old, to a mutilated one, 5 hours old.

Behavior.—9:20. After three-quarters of a minute of absolute quiet, the female and male 58 crawl to the top from opposite directions. At the first attempt he falls, but at once remounts, and as he reaches the top, draws near the female. Her wings now gently but rapidly flutter, sometimes striking the remnants of his wings. Male 41 lies on the floor directly beneath. The female, clinging to the wires with the body in a vertical position, like a boy swinging on a horizontal bar, comes nearer to male 58, and in so doing she turns her body completely about three times, each time bringing her so much nearer to the male. He drops to the floor (no doubt accidentally, being mutilated), while the female clings to the cage just above him, spreading her wings to the fullest extent.—9:26. Male 41 lazily lies at the bottom of the cage; male 58 again attempts to reach the top but stops about half way. At the top the female slowly moves her wings. They are still somewhat moist, and perhaps this movement is really because they are being inflated. Male 58 has resumed his efforts to reach the top where the female rests, and sometimes eagerly moves his stubs of wings; male 41 is fluttering on the bottom of the cage.—9:35. For five minutes male 41 has been flapping his wings, occasionally flitting to the top and throwing himself violently against the female. She flaps her wings as she clings to the dome, and occasionally flies about. At length all are at

rest.—9:37. The female has been nervously fluttering for almost two minutes.—9:39. All are quiet; the female hangs nearer to male 58.—10:10. The female is found to have wandered to the other side of the cage and is now nearer to male 41. At this time we see male 58 (wingless) creeping nearer and nearer to the female, and taking a quiet but firm stand between her and his rival.—May 3, 8:00 A. M. The female is found in copulo with male 58.

The younger insect has again been successful in spite of his wingless condition.

Experiment 14.—May 1, 9:55 P. M.

♂ 6. Age 9 days 7:25 hours.
♂ 7. Age 9 days 7:10 hours.
♀ 55. Age 1 day 6:40 hours.

Object.—To ascertain if a young female, given the choice of two very old males both in apparently like physical condition, will select the one which is younger by only 15 minutes.

Behavior.—9:55. The three insects are placed together, and all join in a general skirmish for two minutes. The two males then become quiet while the female on the floor slowly moves her wings, and just above her clings male 6. Soon male 7, clinging to the wire near the floor, commences to beat his wings violently against the screening.—9:58. Male 6 comes down and flutters about the floor and throws himself bodily against the female.—10:00. Both males are quiet, and the female continues slowly to fan the wings until 10:05. Now she flies to the far end of the cage and with great force throws herself against first one male and then the other. They both pay her no heed whatever, but very soon male 7 gently vibrates his wings.—10:07. Male 7 flies to the female and then to the center of the dome, and there remains. Male 6 lies quietly on the floor.—10:12. The female follows male 7 to the top and flings herself against him repeatedly. Twice he has been knocked to the floor, but each time has promptly remounted. The two now go wheeling and fluttering about each other alternately in circles never quite complete. Male 6 is apparently out of the game, and all are now quiet. May 2, Midnight. The day has passed without an approach to mating.—May 3, 8:00 A. M. The female is found in copulo with male 7, the younger by 15 minutes.

Experiment 15.—May 3, 12:22 A. M.

♂ 62. Age 1 day 8:32 hours. Exceptionally small; wings deformed (see Experiment 11); has severed connection with female 2:22 hours ago.
♂ 63. Age 1 day 8:32 hours. Large and beautiful.
♀ 54. Age 2 days 9:07 hours.

Object.—To see which of two males of exact age, one deformed and having already mated, the other a large, beautiful insect and still unmated, will be chosen by the female.

Behavior.—Male 62 is clinging to the wires of the cage when the others are introduced. He has left off mating only 2 hours ago, but at the "sight" of this virgin female, his wings begin to flutter rapidly. The female does likewise, while male 63, resting on the floor, moves the wings slowly. Male 62 seems extremely eager to remate, for he now flutters to the female, striking her several times, but she creeps nearer and nearer to male 63. Now male 62 flutters wildly about the bottom of the cage, while directly above him clings the female, vibrating her wings with great rapidity. After a short pause, male 62 resumes the excited fluttering and gradually makes his way nearer to the female. Having reached her, he beats his wings against hers and often touches her abdomen with his own. Soon he becomes quiet, and male 63 takes up the commotion, throwing himself first against the female, then against the other male. Fluttering excitedly about the cage, he finally settles down directly in front of the female and majestically moves his wings. The female coldly ignores him. He draws closer to her, and violently flaps his wings against hers.—12:30. After eight minutes of this agitation, all become quiet with male 63 very close to the female. The indications are that these two will mate.—8:00 A. M. The female found in copulo with male 62.

This also shows that it is possible for a male which is young and has just left off mating to mate a second time with a young female. It further shows that the female may mate with a deformed, already mated male instead of a beautiful unmated one of identical age.

Experiment 16.—May 4, 10:00 A. M.

♀ 81. Age 1 day 17:02 hours. Wings slightly damaged.
♀ 82. Age 1 day 17:02 hours.
♂ 74. Age 1 day 19:25 hours.

Object.—Will a male, having the choice of two females of exactly the same age, select the perfect insect or the one with damaged wings?

Results.—2:30 P. M. The male found in copulo with female 82, the normal moth.

Experiment 17.—May 4, 10:30 A. M.

♀ 72. Age 1 day 19:58 hours. Wings removed.
♀ 73. Age 1 day 19:55 hours.
♂..... Age

Object.—Same as Experiment 16.

Results.—May 10, 8:00 A. M. Mating having not taken place during six days, a stray male 108 is introduced.—May 11, 10:00 A. M. This stray male found in copulo with female 73.

No doubt the cold weather was the cause of the sluggishness of this group, and perhaps when the weather became warmer the male was too old to mate. The mean temperature, according to the United States weather reports, for May 4 to 9 inclusive, was 49°, 52°, 52° 50°, 51° and 65° F. The experiment shows that perhaps this or some fault of the male kept them from mating, but under proper conditions on May 11 the stray male chose the perfect insect, which was a few minutes the younger, in preference to the wingless one.

Experiment 18.—May 4, 10:30 A. M.

♀ 68. Age 2 days 15:30 hours. In a badly dilapidated condition, one leg entirely gone and the tarsus lacking on all of the others; the wings are deformed from having hardened before being fully inflated,—hence it can neither cling to the wire cage nor fly. It emerged from a cocoon which lay beneath several others, and in making its way to the top the moist body collected much filth.
♀ 48. Age 3 days 21:25 hours. Large.
♂ 65. Age 2 days 17:30 hours.

Object.—To ascertain if the male will mate with the old normal female or the younger but much dilapidated one.

Results.—May 10, 8:00 A. M. The male found in copulo with female 48.

The cold weather (see Experiment 17) may have hindered mating. This is the first instance in which a male has mated with an older female in preference to a younger one. But when we remember the crippled and filthy condition of the latter, we can easily see why mating was probably impossible.

Experiment 19.—May 4, 11:30 A. M.

♂ 18. Age 5 days 22:40 hours.
♂ 29. Age 5 days 0:40 hours. Antennae removed.
♀ 76. Age 1 day 20:50 hours.

Object.—To determine whether, of two males, the normal or the antennaless one will be the favored or successful mate.

Results.—May 11, 9:00 A. M. They have been observed many times each day for seven days, but mating has not occurred. Thinking that the fault may lie with the female, female 107, aged 15 hours, is introduced. May 19. For eight days these have been together without mating. Male 18 dies.

Experiment 20.—May 4, 10:00 P. M.

♂ 63. Age 3 days 6:10 hours. Wings removed.
♂ 38. Age 5 days 8:00 hours.
♀ 78. Age 2 days 5:20 hours.

Object.—Will the female choose the young, wingless male, or the old normal one?

Results.—May 10, 7:00 A. M. No mating has yet taken place. This may be due to the cold weather.—9:00. The two males are now removed and male 109, of unknown age, is placed in their stead.—May 12, 8:00 A. M. This pair is found in coition.

Experiment 21.—May 5, 10:00 A. M.

♀ 79. Age 2 days 17:10 hours.
♂ 61. Age 3 days 18:10 hours. Previously mated. This is the insect with red abdomen, described in Experiment 12.

Object.—To see whether, under favorable conditions, this male will again mate, having left off mating only two hours ago.

Results.—May 9, 10:00 P. M. Up to this time, mating has not occurred. The low temperature for the five days may be the cause of their lazy behavior. At this time male 35 (age 10 days 8:30 hours) is introduced. May 11, 11:00 A. M. No mating has yet taken place. A marked male, 112, is introduced.—May 12, 8:00 A. M. The insects are still found unmated. Thinking that the fault may lie with the female, I now introduce female 103, about two days old.—May 14, Noon. Still not mated. All the insects except female 79 and female 103 are now removed, and male 109, an insect which has previously mated,

but the only available one, is placed with the two females.—Later. All the insects die without mating.

Experiment 22.—May 9, 10:00 P. M.

♂ 84. Age 0 day 10:10 hours.
♀ 101. Age 0 day 4:50 hours. Wings very ill appearing, dried before being inflated.
♀ 75. Age 7 days 7:20 hours. Beautifully colored.

Object.—To ascertain if a male will mate with a 5-hour-old female whose wings are in a dilapidated condition, in preference to a physically normal one seven days of age.

Results.—May 11, 8:00 A. M. Not until this time is the male found in copulo with female 75.

This is an instance of a normal, old female being preferred to one young and dilapidated.

Experiment 23.—May 9, 10:00 P. M.

♂ 16. Age 11 days 9:10 hours. Wings badly damaged.
♂ 34. Age 10 days 8:30 hours.
♀ 88. Age 0 day 9:50 hours.

Object.—Will the female mate with the dilapidated male eleven days old, or with a perfect male a day younger?

Results.—May 10, 8:00 A. M. The female found in copulo with male 16 in spite of the fact that he is the older and in a very ragged condition.

Experiment 24.—May 9, 10:00 P. M.

♂ 9. Age 12 days 6:00 hours. Wings badly tattered.
♂ 59. Age 8 days 6:20 hours. Wings removed.
♀ 91. Age 0 day 9:14 hours.

Object.—Will the female mate with the extremely old, badly worn male, or one which is 4 days younger, but wingless?

Results.—May 12, 8:00 A. M. No mating having occurred up to this time, the two males are removed and male 39 is placed in their stead.—May 15. Male 39 is found dead; mating has not yet taken place.[5]

Experiment 25.—May 9, 10:30 P. M.

♂ 89. Age 0 day 10:15 hours. Large.
♀ 81. Age 7 days 5:32 hours. Wings slightly damaged.
♀ 93. Age 0 day 9:00 hours.

Object.—Will the male mate with the old or young female?

Results.—Death after two weeks without mating.

Experiment 26.—May 9, 10:30 P. M.

♀ 90. Age 0 day 9:45 hours.
♀ 94. Age 0 day 8:50 hours. Wings slightly crumpled, due perhaps to having been inflated in close quarters.
♂ 33. Age 10 days 9:30 hours.

Object.—Can so old a male mate, and if so, will he select the female with the defective wings or the one in perfect physical condition?

Results.—May 15. Death of male 33. The insects have been kept together 6 days without mating.

Experiment 27.—May 9, 10:30 P. M.

♂ 23. Age 11 days 6:50 hours. Wings badly worn.
♂ 15. Age 11 days 9:43 hours.
♀ 92. Age 0 day 9:43 hours.

Object.—To see which of the males of practically equal age will be chosen or will be victorious—the perfect insect or the one with ragged wings.

Results.—May 10. No mating. Male 5, now over 16 days old, is added.—May 11, 8:00 A. M. Still no mating. The three males are exchanged for a stray male 111.—May 12, 8:00 A. M. The pair found in copulo.

Evidently the three males had lost their vitality through old age, for it seems improbable that the female rejected them all and "waited" for a younger one. It will be remembered that none of these had ever mated.

Experiment 28.—May 12, 11:00 A. M.

♀ 106. Age 1 day 20:30 hours.
♀ 98. Age 2 days 20:00 hours.
♂ 97. Age 2 days 21:00 hours. Left off mating 3 hours previously.

Object.—To see if an already mated male will remate; and if so, will he select the younger of two good females?

Results.—May 13, 8:00 A. M. The male found in copulo with female 106.

This again shows that the male will remate with a young female if he himself is also quite young. In this experiment we see the young female being preferred.

Experiment 29.—May 18, 10:30 A. M.

♂ 122. An unknown insect attracted to the laboratory by the females.
♀ 91. Age 8 days 21:44 hours.
♀ 119. Age 1 day 20:10 hours.

Object.—To see whether the male will mate with the female 9 days of age, or the one of 2 days.

Results.—May 19, 8:00 A. M. The male actually found in copulo with the much older female.

Experiment 30.—May 21, 10:00 A. M.

♂ 129. Age and history unknown.
♀ 95. Age 11 days 20:15 hours.
♀ 127. Age 0 day 22:00 hours.

Object.—To see if the female 1 day old will be chosen in preference to the one 12 days old.

Results.—May 22, 8:00 A. M. The male in copulo with female 127, the younger.

Experiment 31.—May 28, 3:00 P. M.

♀ 123. Age 10 days 2:50 hours. In spite of age, has not yet deposited any eggs.
♀ 128. Age 8 days 2:00 hours. Has deposited some unfertilized eggs.
♂ 131. Age 0 day 1:15 hours.

Object.—To see whether the older virgin female or the younger one, which has oviposited, will be the chosen mate.

Results.—May 29, 8:00 A. M. The male found in copulo with female 128, the younger.

Whether the male mated with this female on account of, or in spite of the fact that she had already oviposited is not known.

Experiment 32.—May 29, 8:00 P. M.

♂ 134. Age 0 day 4:40 hours.
♀ 128. Left off mating one hour previously.

Object.—To see whether an already fertilized female will remate if the male be young.

Results.—May 30, 6:00 A. M. The pair found in copulo.

This is the first and only instance of a female mating with more than one male.

Experiment 33.—May 31, 10:00 P. M.

♂ 138. Age 1 day 6:00 hours.
♂ 139. Age 0 day 8:00 hours.
♀ 140. Age 0 day 7:50 hours.

Object.—To see whether the female will mate with the younger or older male.

Results.—June 1, 6:00 A. M. The female found in copulo with male 138, the older of the two.

Experiment 34.—June 2, 8:00 P. M.

♂ 138. Age 3 days 4:00 hours. Already mated.
♂ 141. Age 1 day 4:50 hours.
♀ 140. Age 2 days 5:50 hours. Previously mated with male 138, having severed only a few minutes before.

Object.—To see if an already mated young female, which has just severed, will mate again, and if so, whether her preference will be for her former mate or for a younger, unmated male.

Results.—June 6, 9:00 P. M. They have been kept together for four days without mating.

Experiment 35.—June 5, 9:00 P. M.

♂ 139. Age 5 days 7:00 hours.
♂ 148. Age 1 day 3:40 hours. Antennae removed.
♀ 144. Age 1 day 5:15 hours.

Object.—To see whether the female will show preference for a normal 5-day-old male or a younger antennaless one.

Results.—June 7, 9:00 A. M. Mating has not yet occurred. It appears that the antennaless male is incapable of mating. Male 163, a normal male of unknown age and history, is now introduced. June 8. The female found in copulo with this stray male.

Experiment 36.—June 6, 9:00 P. M.

♂ 136. Age 8 days 4:50 hours. Mated.
♂ 159. Age 0 day 6:30 hours.
♀ 155. Age 1 day 4:00 hours.

Object.—To see whether a young female will be won by a young, unmated male, or an old, mated one.

Results.—June 7, 7:00 A. M. The female found in copulo with the younger male.

Experiment 37.—June 6, 9:30 P. M.

♂ 160. Age 0 day 7:00 hours.
♀ 153. Age 1 day 5:40 hours.
♀ 158. Age 0 day 7:30 hours. Antennae removed.

Object.—To see if a young male will prefer a normal female aged 1¼ days, or one of 7 hours, but with the antennae removed.

Results.—June 9, 9:00 A. M. After being together for almost 3 days, mating has not yet taken place. In order to ascertain definitely whether an antennaless female can mate, male 160 and female 153 are now removed, and a new male, 173, introduced.—June 10, A. M. This pair found in copulo.

This proves that an antennaless female is quite capable of mating.

Experiment 38.—June 6, 10:50 P. M.

♂ 142. Age 4 days 7:20 hours.
♂ 147. Age 2 days 5:40 hours. Antennae removed.
♀ 150. Age 1 day 9:20 hours.

Object.—To see if mating will take place with the normal male of 4 days, or the antennaless one 2 days old.

If the male finds the female by means of the antennae, the younger but mutilated one will be unable to mate.

Results.—June 7. The female found in copulo with the older but normal male.

It appears that the antennaless male may be unable to find the female.

Experiment 39.—June 6, 9:35 P. M.

♀ 162. Age 0 day 4:35 hours.
♂ 157. Age 0 day 7:35 hours.
♂ 141. Age 5 days 6:25 hours.

Object.—To ascertain whether the older or the younger male, of like condition, will win the female.

Results.—June 7, 9:00 A. M. The female found mated with male 157, the younger.

Experiment 40.—June 6, 10:00 P. M.

♂ 138. Age 7 days 6:00 hours. Mated 5 days previously.
♂ 161. Age 1 day 7:00 hours. Antennae removed.
♀ 151. Age 1 day 7:00 hours.

Object.—To see if the female will mate with the young, antennaless male or a normal mated insect 6 days older.

Results.—June 9, 8:00 A. M. After three nights together they have not mated. There is no reason apparent other than that the antennaless male cannot mate, and the other is too old.[5]

Experiment 41.—June 6, 10:30 P. M.

♀ 152. Age 1 day 7:20 hours.
♂ 143. Age 2 days 7:00 hours.
♂ 154. Age 1 day 6:00 hours. Wings removed.

Object.—To see if the female will mate with the wingless male or the normal, older one.

Results.—June 7. The female found mated with the young wingless male.

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[5] A later experiment proved that the female was not the one at fault. This was also true in Experiments 24, 44, 66, 67, 68 and 69.

Experiment 42.—June 6, 11:00 P. M.

♂ 137. Age 7 days 10:30 hours.
♂ 145. Age 2 days 7:00 hours. One antenna removed.
♀ 146. Age 2 days 6:00 hours.

Object.—To ascertain whether the female will mate with a normal male of 7 days, or one 2 days old with one antenna lacking.

Results.—June 9. They have been together for 3 days without mating. As the cause for this we would suggest that one male is rather old, and the other, having only one antenna, may be unable to locate the female. To make sure that the fault lies with the males and not with the female, they are removed, and male 172 placed in their stead.—June 10, A. M. This pair found in copulo.

Experiment 43.—June 7, 9:00 P. M.

♂ 154. Age 2 days 4:30 hours. A wingless insect which has left off mating only a few minutes previously.
♂ 147. Age 3 days 3:50 hours. Antennaless.
♀ 164. Age 0 day 5:30 hours.

Object.—To see whether the female will mate with an already mated, wingless male, or an unmated, antennaless one.

Results.—June 10. Mating has not yet taken place.

This shows that, in this experiment at least, the mated male as well as the antennaless one cannot mate.

Experiment 44.—June 7, 10:00 P. M.

♀ 149. Age 2 days 9:00 hours.
♂ 143. Age 3 days 6:30 hours.
♂ 165. Age 0 day 5:30 hours. Antennae removed.

Object.—To find whether the female will mate with the normal male or the younger antennaless one.

Results.—June 11. After being together for almost 4 days, mating has not taken place. If it be impossible for the antennales male to mate, male 143 is yet to be had.[5]

Experiment 45.—June 8, 10:00 P. M.

♂ 166. Age 1 day 5:00 hours.
♀ 171. Age 0 day 5:00 hours. Antennae removed.

Object.—To find if an antennaless female will mate.

Results.—June 10, A. M.—The pair found in copulo.

This shows that the antennae of the female are not an essential factor in mating.

Experiment 46.—June 8, 10:00 P. M.

♀ 168. Antennae removed.
♂ 169.

Object.—Same as Experiment 45; to find if an antennaless female is capable of mating.

Results.—June 9, 7:00 A. M. The pair found in copulo after only a few hours.

Experiment 47.—June 8, 8:00 P. M.

♂ 167.
♀ 170. Antennae removed.

Object.—To see if the antennaless female can mate.

Results.—June 9. The pair found in copulo the following morning. again showing that the antennaless female is quite capable of mating.

Perhaps from these experiments we may assume that the male seeks out the female and does so by means of the antennae, the removal of which renders him unable to find her. The removal of the antennae of the female, however, does not affect mating.

Experiment 48.—June 9, 10:00 A. M.

♂ 161. Age 2 days 19:00 hours. Both antennae removed.
♀ 153. Age 3 days 18:10 hours.
♂ 145. Age 4 days 18:00 hours. One antenna removed.

Object.—To find whether youth or the possession of one antenna will give a male the advantage in mating.

Results.—June 10, 10:00 P. M. No mating.

A later experiment proved that the female was not at fault. Hence we may assume that the male with only one antenna as well as the one without any, was incapable of mating.

Experiment 49.—June 10, 7:00 A. M.

♂ 174. Age 0 days 16:00 hours. One antenna removed.
♀ 156. Age 4 days 13:50 hours.

Object.—To find if, when both insects are of favorable age, a male with one antenna can mate.

Results.—June 13. The pair have been together until the present time without mating, which goes to show that this male with only one antenna cannot find the female.

Experiment 50.—June 10, 8:00 A. M.

♂ 175. Age 0 day 17:00 hours. Left antenna removed.
♀ 164. Age 2 days 16:30 hours.

Object.—To find if a male with one antenna can mate.

Results.—June 13. After 3 days, mating has not occurred.

It seems that here again the condition of the antennae of the male, and not the age of the insects, must have been the controlling factor.

Experiment 51.—June 10, 8:00 A. M.

♀ 176. Age 1 day.
♂ 177. Age 0 day 17:00 hours. Right antenna removed.

Object.—Same as Experiment 50, but testing right instead of left antenna.

Results.—June 13. After 3 days mating has not taken place.

Experiment 52.—June 10, 10:00 P. M.

♂ 179. Age 1 day 7:00 hours. Wings slightly torn and left antenna crumpled.
♀ 153. Age 5 days 6:10 hours.

Object.—To see if the deformed antenna of the male will hinder mating.

Results.—June 12, 8:00 A. M. Mating has not taken place after two days.

This female proved her readiness to mate in a later experiment; hence the fault must lie in the defective antenna of the male.

Experiment 53.—June 10, 10:00 P. M.

♂ 161. Age 4 days 7:00 hours. Antennae removed; the insect which did not mate in Experiment 48.
♂ 145. Age 6 days 6:00 hours. Left antenna removed; used previously in Experiment 48.
♀ 181. Age 0 day 9:00 hours.

Object.—To test males lacking one or both antennae for their ability to mate.

Results.—June 13. After 3 days, mating has not taken place.

Experiment 54.—June 10, 11:00 P. M.

♀ 183.
♂ 178. One-half of each antenna removed.

Object.—To see if the distal half of the antennae of the male is essential for mating.

Results.—June 11. The pair in copulo.

Experiment 55.—June 10, 11:30 P. M.

♀ 185. Age 0 day 8:20 hours.
♂ 184. Age 0 day 9:00 hours. Right antenna removed.

Object.—To see if a male with one antenna removed is capable of mating.

Results.—June 11. The pair appear to be mating.—June 18. In my excitement to see if they were actually in copulo June 11, the pair fell to the floor, and if they were, they have never remated, although they have been kept together until the death of the female today.

Experiment 56.—June 10, 11:00 P. M.

♀ 186. Age 0 day 6:10 hours.
♂ 147. Age 6 days 5:50 hours. Antennae removed.

Object.—To test a second time this antennaless male's ability to mate.

Results.—June 13. No mating.

Since we later found this female perfectly good, we must be convinced of the male's inability to mate after two failures.

Experiment 57.—June 11, 8:00 A. M.

♂ 180. One-half of each antenna removed.
♀ 149.

Object.—To see if a male with only one-half of each antenna remaining will mate.

Results.—June 12. 8:00 A. M. In copulo.

Experiment 58.—June 11, 11:00 P. M.

♀ 187. Age 0 day 10:00 hours.
♂ 182. Age 1 day 9:30 hours. Right antenna removed.

Object.—Can this male with only one antenna mate?

Results.—June 15. They have been left together for almost four days without mating.

Since we found soon after, that the female was good, the cause of this was obviously the absence of the antenna of the male.

Experiment 59.—June 11, 11:30 P. M.

♀ 191. Age 0 day 8:00 hours.
♂ 188. Age 0 day 10:00 hours. Both antenna removed.

Object.—To test a male's ability to mate without the antennae.

Results.—June 15. After four days' opportunity, they have not mated.

A later experiment proved that the female was quite capable of mating; hence we may safely assume the cause of its failure to be the antennaless condition of the male.

Experiment 60.—June 12, 8:00 A. M.

♀ 153. Antennaless; used in two previous experiments before the removal of the antennae.
♂ 193.

Object.—To find if the removal of the antennae of the female will hinder mating.

Results.—June 13, 8:00 A. M. The pair in copulo.

Experiment 61.—June 12, 11:00 P. M.

♀ 201. Age 0 day 6 to 9 hours.
♂ 189. Age 1 day 9:00 hours. One-half of each antenna removed.
♂ 204. Age 0 day 6:00 hours. One-half of each antenna removed.

Object.—To see whether the younger or older of two males, having only half of each antenna will mate.

Results.—June 13, 8:00 A. M. The female and the younger male 204 found in copulo.

Experiment 62.—June 13, 8:00 A. M.

♀ 151. Age 7 days 17:00 hours. Both antennae removed.
♂ 205. Age 0 day 15:00 hours. One-half of each antenna removed.

Object.—To find if a male with only one-half of each antenna will mate with an antennaless female.

Results.—June 14, A. M. The pair in copulo.

Experiment 63.—June 13, 8:00 A. M.

♀ 156. Age 7 days 14:50 hours. Both antennae removed.
♂ 190. Age 1 day 17:00 hours.
♂ 175. Age 3 days 17:00 hours. One antenna removed.

Object.—To see if an older, one-antennaed male has any chance to mate in competition with a young, normal insect.

Results.—June 16. The death of the female occurs after three days without mating having taken place.

Experiment 64.—June 13, 8:00 A. M.

♀ 181. Age 2 days 19:00 hours.
♂ 189. Age 1 day 18:00 hours. One-half of each antenna removed.
♂ 202. Age 0 day 15 to 18 hours. One-half of each antenna removed.

Object.—To see if the younger of two males will be more fortunate in mating, when both possess only one-half of each antenna.

Results.—June 16, 6:00 P. M. The insects have been kept together for almost 4 days without mating.

Experiment 65.—June 13, 10:00 P. M.

♀ 216. Age 6 to 9 hours.
♂ 197. Age unknown. One-half of each antenna removed.

Object.—To again test the mating abilty of a male having one-half of each antenna removed.

Results.—June 16. The pair have been kept together for 3 days without mating. Since this male is one of the strays whose history is unknown it may have already been mated.

Experiment 66.—June 13, 10:00 P. M.

♀ 214. Age 0 day 6:00 hours.
♂ 207. History unknown. Right antenna removed.
♂ 208. History unknown. Left antenna removed.

Object.—To see if the absence of left or right antenna will make any difference in mating.

Results.—No mating whatever.[5]

Experiment 67.—June 15, 8:00 A. M.

♂ 182. Age 4 days 18:30 hours. Right antenna removed.
♂ 188. Age 3 days 18:30 hours. Both antennae removed.
♀ 206. Age 2 days 15:00 hours.

Object.—In all previous experiments, males in the same mutilated condition have not mated; this is to test once more their ability.

Results.—June 18, 8:00 A. M. At the end of 3 days, mating has not occurred.[5]

Experiment 68.—June 15, 8:00 P. M.

♀ 232.
♂ 229. History unknown. One-half of each antenna removed.

Object.—To see if the absence of the distal half of each antenna will affect the mating.

Results.—June 18. After being together for 3 days, no mating has occurred.[5]

Experiment 69.—June 15, 8:00 P. M.

♀ 220. Age 1 day 7:30 hours.
♂ 228. History unknown. Left antenna removed.

Object.—To test the mating ability of a one-antennaed male.

Results.—June 18. No mating in the 3 days.

Experiment 70.—June 16, 6:00 P. M.

♀ 248. Age 0 day 1:00 hour.
♂ 244. A stray; history unknown; one-half of each antenna removed.

Object.—To again see if the removal of one-half of the antennae will hinder mating.

Results.—June 18. The pair found in copulo.

Experiment 71.—June 16.

♀ 235. History unknown; both antennae removed.
♂ 240. History unknown.

Object.—To ascertain if the removal of the antennae of the female will hinder mating.

Results.—June 17. The pair found in copulo.

Experiment 72.—June 16, 6:00 P. M.

♂ 241. History unknown. One-half of each antenna removed.
♀ 222. Age 2 days 5:20 hours.

Object.—To ascertain if the absence of the distal half of the antennae of the male will hinder mating.

Results.—June 17. In copulo.

Experiment 73.—June 17, 8:00 P. M.

♀ 254. Age 0 day 8:00 hours.
♂ 247. History unknown. One-half of each antenna removed.

Object.—Same as Experiment 72.

Results.—June 18. The pair found in copulo.

SUMMARY AND CONCLUSIONS.

In answer to our inquiries we find:

1. Males mating with the older or younger female.
   4 males mated the older female (rival seriously defective in two of these cases).
   3 males mated younger female.

2. Females mating with the older or younger male.
   1 female mated the older male.
   10 females mated the younger male (chosen male deformed in six cases).

3. Males mating with the beautiful or unattractive female.
   4 males mated the beautiful female (in two of these cases, rivals in very bad condition; in other two, of equal age).
   1 male mated unattractive female (chosen female was younger).

4. Females mating with the beautiful or unattractive male.
   1 female mated the beautiful male (younger).
   5 females mated the unattractive and deformed male. (All of which were either younger or of the same age as the rival.)

5. Females mating with the normal or wingless male.
   3 females mated the wingless male (all younger).

6. Females mating with antennae removed.
   7 mated.
   1 did not mate.

7. Males mating (a) with one-half of each antenna removed.
   7 mated.
   1 did not mate.

   (b) With one antenna removed.
   12 did not mate.
   1 doubtful.

   (c) Both antennae removed.
   11 did not mate.

By this time the reader must feel how inadequate are the theories in explaining the real occurrences in the living material.

It is at once evident that we do not yet know the attrac-

tion which decides the choice of the insects. We do not know what senses or attractions may exist which we have not perceived.

The experiments bring to light the strength of one factor which has not yet received the consideration due its importance, *viz.*, age. We have matched youth against middle and old age in both sexes, and many times under handicap too, and yet in the majority of cases we see the younger individual, even though seriously defective, winning over the older rival. To just how fine a point this advantage will hold, we cannot safely say, while other factors which determine choice are undiscovered, but in our experiments we find the younger individual still the winner when the difference in ages is only fifteen or even ten minutes.

Theories have been based upon the hypothesis of choice of the beautiful and well qualified on one side and victory by strength on the other. The experiments show in most cases where behavior was noted (and the same was true in a general way in the experiments which could not be recorded in detail) that the female exercised no choice. In the few cases where her choice was evident, it was surprisingly varied; she showed her preference for the plain or even pitifully defective or mutilated mate as readily as for a fine, perfect one.

The males, perhaps, show a little more choice in the matter, yet here too youth is the element which decides more "matches" than any other, so far as we can see.

But we must not lose sight of the fact that, while selection clearly works toward youth, this does not necessarily mean working toward the more fit in individual variations, because it is only a matter of chance whether the beautiful one is the younger when the competition occurs. But here we are again left in doubt about the extent to which the male selects by victory of strength when we see the young, wingless males winning almost every time over the normal ones.

Mayer[6] has given us good evidence that the sense of smell, rather than sight, plays a large part in mating. Our experiments upon the removal of the antennae quite substantiate his work, for in every case where both antennae of the male were removed, mating did not occur. The condition was the same where only one was removed, but the removal of one-half of each antenna seems to offer no hindrance to mating, nor does the absence of both antennae of the female.

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[6] Mayer, A. G., Psyche 9 : 15. 1900.

FURTHER OBSERVATIONS ON COPULATION AND OVIPOSITION IN SAMIA CECROPIA LINN.*

PHIL RAU.

During the spring of 1910 a study of the duration of life of *Samia ceropia* Linn. was in progress. In connection with this it was convenient to gather a large amount of data to supplement the observations published last year.[1]

The 205 cocoons came from the same locality as before. They were kept under wire dish-covers, and the insects emerged at intervals from April 13 to June 17.

I. OBSERVATIONS ON COPULATION.

1. LENGTH OF TIME SPENT IN COPULO.

Mating usually commenced between midnight and morning, and with very few exceptions, ended at those hours on the following day. These hours were such as to make exact observations impossible.

Tabulation shows that the time spent in copulo varies from 10 to 48 hours, with one case of 72, the average being 21 hours. This agrees exactly with the observations of the previous year.

Two cases occurred which were strikingly exceptional. One pair remained in copulo without separation for 72 hours and then mated three times after that, the last time remaining in copulo 10 hours. This was the most extreme case of remating observed. The other pair also

*Read before the Entomological Section, October 27, 1910, and presented by title to The Academy of Science of St. Louis, April 3, 1911.

[1] Trans. Acad. Sci. St. Louis, 19 : 21-48. 1910.

remated three times. The female died and the male continued in copulo with the dead body for about seven hours.

2. THE SPECIES SEEM TO BE MONOGAMOUS.

In my work of the previous year I found it impossible to mate one male with more than one female, or *vice versa.* After reading that in Miss Soule's[2] experience "* * * eleven males mated * * * and then mated a second female each eight hours later," I gave each insect, wherever possible, the opportunity to mate a second time either with the original mate or with another, which, in some cases, was yet unmated and in others had been previously mated. As a result of these experiments I found the species to be monogamous, that is, each male mating with but one female, and each female mating with one male, with but the following exceptions:

3 males mated with the original female 2 times.
1 male mated with the original female 3 times.
2 males mated with the original female 4 times.
1 male mated with the original female 5 times.

These are simple rematings. The following are the only cases of true polygamy:

1 female mated with 2 males 1 time each.
3 males mated with 2 females 1 time each.
1 male mated with 3 females 1 time each.

Whenever cases of true polygamy occurred, the later mating was always with an individual which was still unmated and very young, and in almost every case it was only when the new insect was placed in the cage just a few hours after the first mating had terminated.[3]

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[2] Psyche, 9 : 224.

[3] The exact number of opportunities given the pairs to remate was 58. Besides this, upwards of 100 experiments were made to see if mated individuals would again mate with unmated ones or with others already mated.

To summarize then, only seven pairs remated with their original mates, four males mated with more than one female, and only one female mated with more than one male.

From so large a series of experiments, and from the fact that in only a few instances and under exceptional conditions mating occurred more than once, I think we must conclude that the species is monogamous. In this decision we need not be disconcerted by the small percentage of cases of remating, when we consider the unnatural conditions under which the experiments must necessarily be carried on. In nature, where the male must expend in finding the female much vital energy, which is not replenished by taking food or drink, mating may occur but once. In 1909 I was led to observe whether the males were polygamous or monogamous by observing that the males were greatly in excess of the females. At first it was thought that many males were required to fertilize one female, but it was later observed that the insects were not polygamous. In the work of this year the sexes appeared in about equal numbers: 101 males to 104 females.

The aforementioned author was led to observe that the males were polygamous from the fact that in "most of the collection of *Cecropia* cocoons * * * the female pupae outnumbered the males by five to one, and twice by three to one." "For this reason," the author says, "I inferred that the males were polygamous." While it is shown that eleven males mated two females each, it is not shown how many insects, if any, refused to remate.

In my previous work I suggested that at one time the species may have been polygamous. May it not be possible that those few exceptional individuals which mated often may have exhibited this primitive trait?

3. AGE OF INSECTS WHEN MATING BEGAN.

The object of these experiments was to ascertain at how late or how early an age it was possible for mating to occur. Had the insects been free to choose for themselves, perhaps they would not have waited so long, or in some cases mated so soon, as the figures show.

(a) *Females.*

Age.	No. Mating	Age.	No. Mating
10 days	4	4 days	6
9 days	5	3 days	5
8 days	1	2 days	9
7 days	2	1 day	4
6 days	1	16-20 hours	9
5 days	5	13-14 hours	5

The table shows that the ages of the 56 females when mating occurred varied from 13 hours to 10 days. Soule found that it requires 16 hours out of the cocoon before the female is ready to mate. This lot of material contained five females which mated at an earlier age, 13 hours in one, and 14 hours in four instances.

(b) *Males.*

Age.	No. Mating.	Age.	No. Mating.
12 days	1	3 days	3
11 days	1	2 days	15
9 days	1	16-20 hours	5
5 days	1	12-15 hours	5
4 days	1		

The age at mating of these 33 males was found to vary from 12 1-6 hours to 12 days. It will be seen that mating can occur in the male at a later age, and also at a slightly earlier age, than in the female.

II. Observations on Oviposition.

1. Number of Eggs Deposited.

(a) *Fertilized Females.*

The following table shows the number of eggs deposited by each of 52 fertilized females:

476	344	298	244
445	343	295	243
435	340	295	229
398	339	294	228
396	334	291	228
384	327	284	228
372	326	283	220
370	324	282	220
368	308	280	211
366	305	279	203
360	302	266	181
357	301	258	145
354	301	247	103

It will be seen that the number of eggs varies from 103 to 476, while the average is a fraction over 300. In comparing these numbers with those of the previous year, we find in this season's count a greater range of variation, while the average is greater by 37.

(b) *Unfertilized Females.*

Following is the number of eggs deposited by each of the 19 unfertilized females:

422	246	169
359	243	166
356	238	163
329	198	156
323	196	106
296	179	73
294		

Thus the numbers range from 73 to 422, averaging 237. This is greater than the average for 1909 by about 80, but being based on a larger series of material, is more significant.

(c) *Comparison of oviposition in fertilized and unfertilized females.*

The question whether the number of ova deposited be equal in fertilized and unfertilized females is of some interest.

In 1909 I found the average number of eggs deposited by the fertilized female to be the greater by 106. In this season's work upon a larger series of material, I found the same to be true by a difference of 63. Thus the fertilized females oviposited more abundantly, in spite of the fact that some of the time which a mated female might have spent in ovipositing was spent in long copulation. This shows that copulation, more than the time available, influences completeness of oviposition.

2. NUMBER OF EGGS RETAINED AFTER DEATH.

(a) *Fertilized Females.*

Below is given the number of eggs dissected from the fertilized females after death.

240	54	12
165	41 in 2 cases	10
151	34	9 in 2 cases
119	31	8 in 3 cases
105	29	7
101	27	6
95	22	5 in 3 cases
94	20 in 2 cases	3 in 3 cases
93	18	2
80	15	1 in 3 cases
72	14	0 in 7 cases
56	13	

The number of eggs retained by the 52 insects varies from 0 in seven instances to 240, the average being 36. This is less than the corresponding number for 1909 by about 15.

(b) *Unfertilized Females.*

The table shows the number of ova retained by the unfertilized females.

270	103	40
257	102	37
247	100	32
189	85	31
179	80	23
144	68	21
137	62	17
135	53	2
133	48	2
110		

The numbers varied from 2 to 270, averaging 96, which accords well with the data for 1909.

(c) *Comparison of the Number of Ova Retained by Mated and Unmated Females.*

The mated insects retained the smaller number of eggs after death. A glance at the numbers in the two tables will at once make this clear, and the average for the fertilized females was 36, against 96 for those unfertilized. In the unmated insects I found none which oviposited completely, while among those which were fertilized seven oviposited perfectly. Again, in the unmated insects I found only five which retained 23 eggs or less; in the mated group there were thirty-three which retained less than that number.

3. ENTIRE NUMBER OF EGGS PRODUCED BY FEMALES.

The count was made on 64 insects, and the total number of eggs produced by each female was obtained by adding the number of ova deposited to the number retained at death.[4]

[4] The numbers are thrown into groups of ten, 300 to 309, 310 to 319, etc.

No. Eggs	♀'s	No. Eggs	♀'s	No. Eggs	♀'s
480	1	370	4	290	3
460	3	360	3	280	1
450	1	350	2	270	3
430	4	340	4	260	2
420	4	330	3	250	3
410	1	320	4	240	3
390	3	310	3	210	1
380	2	300	5	200	1

The average for these figures is 344, which is greater than the corresponding number for last year by 52.

4. THE RELATION OF EARLY OR LATE EMERGING TO THE NUMBER OF EGGS PRODUCED.

It was found that the early emerging moths lived long lives, while those which emerged late lived a shorter time.[5] We also know that the number of eggs produced by each individual varied from 203 to 486. The question of interest is to find whether large production of ova is correlated with late or early emerging, which is synonymous with short or long life. One might suppose that the late emerging insect would produce many eggs from the fact that it had a longer time for forming them. At the same time one might equally well suppose that the early emerging female would deposit many ova from the very fact that it lived longer. We might think from the standpoint of natural selection that those which live long enough to deposit many eggs would predominate and perpetuate a long-lived race.

After careful calculation, however, absolutely no relation between the number of eggs and early or late hatching, or long or short life, was found.

5. NUMBER OF DAYS SPENT IN OVIPOSITING.

In 57 mated females I found the number of days spent in ovipositing to vary from 3 to 15. In the 20 unmated

[5] The results of the observations on the duration of life are in course of preparation.

females the conditions were quite the same. The interesting fact is that the number of days spent in ovipositing by the long lived and also by the short lived insects is in no way correlated with the length of life.

6. AGE OF THE INSECTS WHEN FIRST EGGS WERE DEPOSITED.

Long lived insects.

Age Days	No. of mated ♀'s	No. of unmated ♀'s	Total
2	3	0	3
3	3	2	5
4	1	0	1
5	4	1	5
6	3	2	5
7	0	2	2
8	0	1	1
9	0	2	2
10	2	2	4
11	2	0	2
12	0	0	0
13	0	1	1

Short lived insects.

2	11	5	16
3	5	6	11
4	5	8	13
5	0	4	4
6	0	1	1
7	0	2	2
8	0	1	1

Hence we see that the age of the female at first oviposition varied from 2 to 13 days, regardless of whether or not fertilization had occurred.

Notes were made on 79 insects, 40 of which partially oviposited before mating. In the unmated, long-lived individuals, the age at first oviposition varied from 3 to 13 days, while in the short-lived group it varied from 2 to 8 days. We see some unmated insects beginning to oviposit very early in life, and others of the long-

lived individuals holding off until the age of 10 or even 13 days, as if "waiting" to be fertilized.

Oviposition, it seems, is regulated by physiological conditions of the individuals, but the table shows that the short-lived insects deposit unfertilized eggs at an earlier age than the long-lived ones.

7. THE RELATION OF DURATION OF LIFE, TIME SPENT IN COPULO AND AGE OF FEMALE AT TIME OF MATING, TO THE NUMBER OF EGGS RETAINED AT DEATH.

(a) *Relation of duration of life to eggs retained.*

A careful examination of the data shows that there is absolutely no relation between long life and perfect oviposition, and short life and imperfect oviposition. One would naturally think that the long-lived insects would have ample time to lay all their eggs, while, perhaps, the short-lived moths could only partially oviposit, but this does not seem to be the case. The proportions of cases of complete and incomplete oviposition are about equal in the long and short-lived groups. In the 1909 notes the conclusion that such a correlation existed in the unmated females was based upon an altogether insufficient number of observations—only 4 against the 28 of this year. Among the 52 mated females of this year no relation was ascertained between long life and perfect oviposition.

(b) *Time spent in copulo and eggs retained.*

The 1909 conclusions are confirmed in this year's evidence that a longer or shorter period of copulation does not influence the number of eggs deposited or the number retained after death.

(c) *Age of the female at mating and eggs retained.*

In the notes of 1909 I found the appearance of such a relation. If the female mated early in life, oviposition was almost complete; if late, many eggs were retained. This inference was drawn from 7 instances.

In this year's work 51 insects were observed. Here I found absolutely no relation between the age of the female at mating and the number of ova retained at death. Among those which mated at an old age, some retained many eggs, while in others, oviposition was perfect. Likewise among those which mated early in life all degrees of completeness of oviposition were observed.

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