TRANSACTIONS

OF THE

ROYAL SOCIETY OF SOUTH AFRICA

VOLUME III.

1913.

WITH TWENTY-TWO PLATES.

CAPE TOWN:

PUBLISHED BY THE SOCIETY.

1913.

LONDON
PRINTED BY WEST, NEWMAN AND CO.,
HATTON GARDEN, E.C.

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Issued January 30th, 1913.] [Price 17s.

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VOL. III.

A REVISION OF THE GENUS *ALEPIDEA*, Delaroche.

By R. Dümmer.

(Communicated by Prof. H. H. W. Pearson. Read May, 15, 1912.)

(Plate I.)

In undertaking the revision of this genus I have availed myself of the exceptional facilities prevailing at Kew and at the British Museum for work of this nature, and I gladly avail myself of this opportunity of expressing my indebtedness to the authorities of these institutions.

Mr. Medley Wood, Director of the Natal Herbarium, courteously communicated several herbarium specimens from that region, among which two species new to science were included. My thanks are also due to Mons. F. Gagnepain, of the Paris Herbarium for making my brief stay at that institution as profitable as possible, and in conclusion I tender my deep obligations to Mr. N. E. Brown, of the Kew staff, who has most kindly given me the benefit of his valuable advice and criticism.

Alepidea is an umbelliferous genus comprising approximately 23 species, all natives of Africa, most closely allied to Eryngium, a widely diffused group, from which it differs, however, in the more or less flattened receptacle, the absence of additional involucral bracts and the lack of bracteoles between the flowers—a character expressed by the generic name. Founded in 1808 by Delaroche on a specimen from the "Cape of

Good Hope" and described and figured by him in his "Historia Eryngiorum," the species *A. ciliaris* was prior and even subsequently confounded with the genus *Astrantia*, Baillon reducing it to *Eryngium* in 1880, while Bergius united it with *Jasione*, overlooking the characteristic structure of the ovary and adjacent parts. Three of the pioneers of South African botany, Drège, Ecklon, and Zeyher, contributed four other species —*A. longifolia*, E. Mey., *A. cordata*, E. Mey., *A. amatymbica*, and *A. serrata*, Ecklon and Zeyher—which were subsequently reduced by Sonder in the Flora Capensis to two, viz.: *A. amatymbica*, Eckl. and Zeyh., and *A. ciliaris*, Delaroche, but from an examination of the typical forms of these five proposed species, I am disposed to regard them as distinct. A new species, *Alepidea Thodei*, collected by Thode at Mont aux Sources on the Drakensberg Range and subsequently by Galpin on Ben MacDhui at 8,800 to 9,900 feet above sea-level, exhibits unmistakable affinities with the Abyssinian *A. peduncularis*, Steud.

The *distribution* of the species is obviously coastal, extending in a south-westerly direction to the districts of Swellendam and in a northerly as far as Abyssinia, where, curiously enough, the prevailing species *A. peduncularis*, Steud., appears to have been only collected by Schimper, a German naturalist, held captive by the Abyssinians for several years. The greatest concentration of the species south of the tropic is in the Natal Region, but whether they are gregarious or not I am unable to say. Their *economic properties* are limited; Wood and others state that the leaves of several species, including *A. Baurii*, O. Kuntze, known as "Ikokwane" or "Ikokwaan," are eaten either cooked or raw by the natives, while the tropical species *A. propinqua*, Dümmer, according to Buchanan, yields a kind of salt after the ashes of the roasted leaves have been washed; on the authority of Galpin, the roots of *A. amatymbica*, Eckl. and Zeyh., are used by the natives as a cure for dysentery.

ALEPIDEA, Delaroche.

Flowers in heads, hermaphrodite or rarely unisexual, regular, sessile or subsessile, crowded, 7–30 in a head. Receptacle nude, flat or slightly convex. Calyx superior, 5-toothed; teeth persistent, erect, deltoid or membranous, acute to mucronate, keeled, often papillate. Petals 5, free, epigynous, oblong with an abruptly inflexed point forming a slight notch at the point of inflexion, keeled within, deciduous, white. Stamens 5, free, epigynous; filaments filiform, slightly dilated at the base; anthers introrse, oblong, 2-celled, dorsifixed, longitudinally dehiscent. Ovary 2-celled with a pendulous ovule in each cell. Styles 2, erect or reflexed, stout or filiform, obtuse, truncate or slightly capitate. Fruit ovoid, obovoid or suborbicular, occasionally compressed, more or less distinctly

10-ribbed, smooth, muricate entirely or only at the apex or on the ribs, ochreous or dark brown, shining or dull, splitting into 2 mericarps, flattened on their inner face and adnate to an undivided carpophore, which occasionally separates and persists on the mature receptacle; vittæ 10, marginal, seated under the ridges.

Glabrous herbs with short ligneous rhizomes and fibrous or subfleshy fascicled roots; stems solitary, erect, slender or robust, terete or angular and grooved, fistular, simple at the base, umbellately, racemosely or paniculately branched above, with the ultimate branchlets either smooth or minutely scaberulous. Leaves alternate, undivided, rigid or flexible, glabrous, all sessile or the radical stalked; cauline distant or imbricate, amplexicaul, adpressed or spreading, reticulated, coarsely or ciliately toothed or margined with slender or stout bristles. Flower-heads solitary, few or many subumbellately disposed on the ends of the branches, congested or spreading, involucrate. Involucre-segments 5–15, united at the base or to their middle, in one or two series, obtuse to acuminate entire or occasionally toothed, keeled and often veined, coriaceous or papery, stellately spreading or ascending, exceeding the flowers.

Alepidea, Delaroche, Eryng. Hist. 19, t. 1, 1808. Poiret in Lam. Encyl. Supp. I. 288, 1810. DC. Prod. IV. i. 87, 1830. Don. Syst. Bot. III. 266, 1834. Endl. Gen. II. 767, 1836. Meisn. Gen. 141, 1836–43; Harv. Gen. S.A. Plts. 133, 1838; Spach Hist. Veg. VIII. 139, 1839; Spach in D'Orb. Dict. I. 307, 1841; Gay Eryng., Nov. 6, 1848. Sond. in Fl. Cap. II. 533, 1862. Bth. et Hk. f. Gen. Pl. I. iii. 878, 1867. Baillon Dict. I. 94, 1876. Hiern in Oliver Fl. Trop. Afric., III. 7, 1877; Drude in Engl. and Prantl Pflans Fam. III. 8, 139, 1898. Wood Handb. Fl. Nat. 56, 1907. Thonner Blütensfl. Afr. 429, 1908. *Alepida*, O. Kuntz. Rev. Gen. III. ii. 110, 1898. *Astrantia*, Linn. f. Supp. 117, 1781. Linn. Syst. Veg. 272, 1784. Thunb. Prod. 49, 1794. Persoon Syn. Pl. I. 304, 1805. Thunb. Fl. Cap. II. 196, 1818. Schult. Syst. Veg. VI. 343, 1820. *Eryngium*, Baillon Hist. Pl. VII. 240, 1880. *Jasione*, Berg. Act. Ups. III. 188, 1780.

Key to Species.

I. Expanded involucre $\frac{1}{2}$–$\frac{3}{4}$ in. in diameter with 5–10 equal or unequal segments.
  a. Stem equally leafy throughout its entire length.
    *Stem, robust 3–8 ft. high; lower cauline leaves 5–12 in. long, 1–3 in. broad.
      Teeth of the leaf-margin entire. Involucre of 5 large subequal segments with small alternating teeth, calyx-teeth rudimentary, $\frac{1}{8}$–$\frac{1}{7}$ line long .. .. 1. *amatymbica.*
      Teeth of the leaf-margin bi- or trifid. Involucre of 10 large subequal segments; calyx-teeth $\frac{1}{3}$–$\frac{1}{2}$ line long .. .. 2. *Macowani.*
    **Stem slender, $\frac{1}{2}$–$2\frac{1}{2}$ ft. high; cauline leaves imbricate, the lower $\frac{1}{5}$–3 in. long, $\frac{1}{12}$–$\frac{1}{2}$ in. broad.

†Radical leaves petiolate, spreading, not ciliate.
Stem narrowly paniculately branched from near or below the middle; flower-heads numerous; cauline leaves 2–3 in. long .. .. 3. *Jacobsziæ*.
Stem corymbosely or racemosely branched towards the apex; flower-heads few; cauline leaves $\frac{1}{2}$–1 in. long.
Stem corymbosely branched; calyx-teeth $\frac{1}{7}$–$\frac{1}{8}$ line long .. .. 4. *setifera*.
Stem racemosely branched; calyx-teeth $\frac{1}{3}$ line long.. 8. *gracilis*.
††Radical leaves subsessile, rosulate, densely ciliate.
Stem $\frac{1}{2}$–$\frac{3}{4}$ ft. high, clothed with bristle-margined leaves, $\frac{1}{5}$–$\frac{1}{3}$ in. long .. .. 21. *concinna*.

b. Stem leafy towards the base, the upper cauline leaves usually inconspicuous and distant.
†Leaves coriaceous, serrate; stem more or less terminally branched; branches invariably stiff.
Branches of the inflorescence 2–3 in. long; leaves coarsely serrate-setose; larger involucral segments about 1 line broad .. .. 5. *longifolia*.
Branches of the inflorescence 1 in. long; leaves closely and finely serrate-ciliate; larger involucral segments $1\frac{1}{2}$ line broad .. .. 7. *coarctata*.
††Leaves thin, dentate; stem invariably branching from near or below the middle; branches lax and slender.. .. .. 6. *propinqua*.

c. Stem subnude, $\frac{1}{2}$–2 ft. high; cauline leaves obsolete; developed leaves chiefly radical.
†Leaf-margin obviously toothed or with rigid bristles; segments of the involucre usually 10, equal or unequal.
Bristles between the teeth often inflexed and adpressed to the upper leaf surface.
Leaves cordate-oblong, dentate or crenate-dentate, teeth regular .. .. 11. *ciliaris*.
Leaves linear-lanceolate, serrate, often irregularly toothed .. .. 12. *serrata*.
No bristles between the teeth.
*Stem terminally branched.
Leaves lanceolate, tapering to the base.. .. .. .. 16. *comosa*.
Leaves oblong, rounded or cordate at the base.
Segments of the involucre equal; leaf-margin serrate; calyx-teeth $\frac{1}{3}$ line long .. .. 15. *Swynnertonii*.
Segments of the involucre unequal; leaf-margin crenate-dentate; calyx-teeth $\frac{1}{6}$–$\frac{1}{7}$ line long .. .. 14. *Galpinii*.
**Stem branched from below the middle; leaves oblong, obovate to oblanceolate.
Involucre when expanded not exceeding $\frac{1}{2}$ in. across.
Petiole terete, slender; leaf cordate at the base; marginal teeth keeled .. .. 13. *cordata*.
Petiole flattened, 2–3 lines broad; leaf attenuate at the base; teeth not keeled.
Leaf-teeth triangular; calyx-teeth obtuse .. .. 9. *Woodii*.*
Leaf-teeth narrowly subulate: calyx-teeth acute 10. *Tysonii*.*
Involucre when expanded exceeding $\frac{1}{2}$ in. across.

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* Cauline leaves may occasionally be developed in these two species.

Marginal bristles close; involucral segments dingy brown .. .. 17. *longeciliata.*
Marginal serratures distant; involucral segments pale lilac.. .. .. 18. *Wyliei.*

††Leaf-margin entire or denticulate, distinctly ciliate; segments of the involucre 5, equal, rarely alternating with triangular teeth.
Leaves thin; margin entire .. .. 19. *Baurii.*
Leaves coriaceous; margin denticulate or obscurely serrate 20. *natalensis.*

II. Expanded involucre 1 in. or more in diameter, with 10–15 irregular segments.
Plant with numerous flower-heads; segments of the involucre united only at the base; cauline leaves conspicuous; radical leaves crenate-dentate; teeth tipped with awn-like setæ .. .. 22. *peduncularis.*
Plant with one to three flower-heads; segments of the involucre united to their middle; cauline leaves obsolete; radical leaves coarsely serrate or dentate-setose .. .. 23. *Thodei.*

1. Alepidea amatymbica, Ecklon and Zeyher, Enum. Pl. 339 (1835).

A glabrous plant with a robust, erect, hollow, grooved, and leafy stem, 3–7 ft. high, racemosely or paniculately branching from below the middle; branches occasionally short but more often long and slender, exceeding $\frac{3}{4}$ ft. in length, ascending—spreading, with the ultimate branchlets minutely scaberulous or smooth. Leaves more or less herbaceous, large, pale olive-green with very prominent venation on the lower surface; margin finely or coarsely dentate, teeth triangular, acute, $\frac{1}{12}$–$\frac{1}{4}$ in. long: radical laxly spreading, petiolate; petiole flattened and winged, 3–7 in. long, $\frac{1}{4}$ in. broad, entire, widening towards the base and clasping the stem; blade 4–5 in. long, 2 in. broad, oblong, rounded at both ends; cauline leaves sessile or rarely subpetiolate, distant or imbricate, adpressed or spreading, oblong to oblong-cuneate or spathulate, the lower 4–12 in. long, 1–3$\frac{1}{2}$ in. broad, the upper decreasing in size, auriculate with coarser toothing. Flowers—heads numerous, compound—umbellately disposed, congested, or scattered, 7–10-flowered, $\frac{1}{3}$–$\frac{1}{2}$ in. diameter. Involucre usually of 5 spreading or incurved, acute or acuminate, entire, coriaceous, keeled and nerved segments, with smaller triangular teeth occasionally alternating, pale olive-green without, pale yellow within. Calyx-teeth obsolete, $\frac{1}{6}$th line long, deltoid. Styles variable in length, erect or reflexed. Fruit smooth or slightly muricate at the apex, ovoid or suborbicular. Carpophores occasionally persisting on the mature receptacle. Dietrich Syn. Pl. II. 935, 1840. Walp. Repert. II. 389, 1843. Sond. in Fl. Cap. II. 534, 1862, excl. syn. *Alepidea amatymbica* var. *cordata*, Sond. in Fl. Cap. II. 534, 1862. *Alepida amatymbica* and var. *cordata.* O. Kuntze, Rev. Gen. III. ii. 110, 1898. *Alepida aquatica*, O. Kuntze, *l.c.*

South Africa. Beaufort Div.: Summit of the Winterberg Range, *Ecklon*, 2189 (partly)! Stockenstrom Div.: Kat Berg, *Hutton!* Zuurberg Range, *Burke!* Orange River Colony: *Cooper*, 1017! Dornkop, near the Sand River, *Zeyher*, 728! Transvaal: Montrosa, near Barberton, 4,500 ft., *Galpin*, 1344! Witpoortje, near Johannesburg, *Rand*, 1225! Griqualand East: In damp places on the mountains about Clydesdale, 3,000 ft., *Tyson*, 2737! and in Herb. Austr.-Afr., 1276! Tembuland: Grassy slopes near forests, Mount Bazeia, 2,500 ft., *Baur*, 115! Natal: In damp places near Byrne, *Wood*, 340! In dense scrub near Enon, 3,000 ft., *Wood*, 1850! Zululand: Umloti, *Gerrard*, 1255!

2. A. Macowani, Dümmer, sp. nov.

Glaberrima, circiter 1 met. alta. Caulis teres, sulcatus, foliatus, divaricato-ramosus, ramis erecto-patentibus 5–15 cm. longis. Folia radicalia, 30 cm. longa, 3–5 cm. lata, auguste oblonga, apice rotundata, basin versus in petiolam brevem attenuata, grosse dentata, dentibus bifidis vel trifidis acuminatis; caulina amplexicaulia, remota. Involucri segmenta 10, subæqualia, acuta, valde carinata nervataque, coriacea. Calycis dentes, ·7 mm. longæ. Fructus ad apicem leviter muricatus.

An erect, entirely glabrous plant, 3½ ft. high, with a terete grooved divaricately branched leafy stem; branches ascending and spreading, 2–6 in. long. Radical leaves narrowly oblong, 13 in. long, 1½–2 in. broad, rounded at the apex, tapering gradually into a short petiole at the base, coarsely toothed, with bifid or trifid acuminate teeth; cauline leaves, amplexicaul, remote, ascending, slightly auriculate. Segments of the involucre 10, subequal, acute, strongly keeled and nerved, coriaceous. Calyx-teeth, ⅓ line long, broadly ovate, apiculate. Fruit slightly muricate at the apex. *A. amatymbica*, Ecklon and Zeyher, *l.c.* (in part).

South Africa. Bedford Div.: On the summit of the Kaga Berg, 3,200 ft., *MacOwan*, 1117! Fort Beaufort Div.: Winterberg Range, *Ecklon*, 2189 partly, in Herb. Paris! Somerset East Div.: Bosch Berg, *Scott-Elliott*, 432!

This species was included in the set of *Alepidea amatymbica*, 2189, distributed by Ecklon and Zeyher, but is obviously distinct, the bifid or trifid marginal teeth of the leaves, the involucres of ten subequal segments and the larger calyx-teeth being the most salient points of distinction. It commemorates the name of the late Professor P. MacOwan, the distinguished Cape botanist.

3. A. Jacobsziæ, Dümmer, sp. nov.

Caulis erectus, 6 dm. altus, multicephalus, foliatus, anguste paniculato-ramosus, ramis plurimis horizontalis vel adscendentibus 2·5–5 cm. longis, ramulis ultimis scaberulis vel lævibus. Folia radicalia pauca, petiolata; petioli 5 cm. longi, lamina 5–7·5 cm. longa, 2 cm. lata, oblonga, apice rotundata, basi subcordata, margine obscure serrato-setosa; caulina conferta, imbricata, amplexicaulia, glabra (5–7·5 cm. longa, 6–12 mm. lata, ovato-lanceolata vel anguste lanceolata, acuta vel cuspidata, basi auriculata, margine grosse serrato-setosa, setis rigidis 6–8 mm. longis, flavis. Involucri segmenta 6–10, sæpe 8 mm. longa, rigida, acuta vel acuminata, carinata et nervata, aliquando scaberula. Calycis dentes minutæ. Styli 0·5 mm. longi, capitati vel truncati. Fructus dense-muricatus, aliquando muricato-costatus.

Stem approximately 2 ft. high, erect, angular at the base, densely leafy, branching from near or below the middle into a narrow, more or less cylindrical panicle; branches 1–2 in. long, horizontal or ascending with the ultimate branchlets often scaberulous. Radical leaves few, petiolate; petiole 2 in. long, entire; blade 2–3 in. long, $\frac{3}{4}$ in. broad, oblong, rounded above, slightly tapering or cordate at the base, obscurely serrate-setose, the setæ 1 line long, rigid; cauline numerous, imbricate, adpressed or ascending, 2–3 in. long, 3–6 lines broad, ovate-lanceolate or lanceolate, acute or acuminate, auriculate at the base; margin serrate-setose; setæ awn-like, rigid, 3–4 line long, ochreous. Flower-heads numerous, $\frac{1}{3}$–$\frac{3}{4}$ in. in diam. Involucral segments 6–10, occasionally more, rigid, acute or acuminate, with cartilaginous margins, keeled and veined. Calyx-teeth minute. Styles capitate or truncate at the apex. Fruit densely muricate or often muricately ridged. *Alepidea*, sp., Wood, Handb. Fl. Natal, 57, 1907; in Trans. South Afr. Phil. Soc., XVIII. pt. 2, 161, 1908.

South Africa. Orange River Colony: Bester's Vallei, Witzie's Hoek, 5,400 ft., Miss *Jacobsz* in Herb. Bolus, 6344! Harrismith, *Sankey*, 73! Natal: Near Hoffenthal, 4,000 ft. Weenen County, *Wood*, 3502!

The large, narrow, paniculately-branched densely leafy stem and numerous flower-heads distinguish this species from *A. setifera*, N. E. Brown.

4. A. SETIFERA, N. E. Brown in Kew Bull. 161 (1896).

Stem erect, slender 1–1$\frac{1}{2}$ ft., densely leafy, corymbosely branched; branches few, 1–2 in. long, distinctly scaberulous or occasionally smooth. Radical leaves few, petiolate, spreading; petiole flattened or channelled, $\frac{1}{4}$–1 in. long, clasping the base of the stem; blade 1–1$\frac{1}{2}$ in. long, $\frac{1}{4}$–$\frac{3}{4}$ in. broad, linear-oblong or elliptic, acute or obtuse; margin dentate or serrate-setose; stem-leaves numerous, imbricate, more or less adpressed, amplexicaul, auriculate, linear-lanceolate or ovate-lanceolate, glabrous with dentate-setose margins; setæ rigid. Flower-heads few, 13–15 flowered. Involucre of 8–10 irregular rigid acuminate keeled smooth or scaberulous segments, $\frac{1}{6}$–$\frac{1}{3}$ in. long. Calyx-teeth minute. Fruit muricate or rarely smooth. *A. ciliaris*, Engler in Engler and Drude's Veg. der Erde IX. i. i. 453, t. 381, 1910 (not Delaroche).

South Africa. Natal: Near Greytown, 3,000–4,000 ft., *Wood*, 5,985! On a hill near Van Reenen, *Wood*, 5630! Newcastle, *Wood*, 6655! Transvaal: In swampy ground of the Umlomati Valley, Barberton, *Galpin*, 1290! Hoggeveld, Page's Hotel, *Rehmann*, 6849! Swazieland: High Veld near Dalriach, 4,400 ft., *Bolus*, 11,919!

The foliose slender stems, corymbosely-branched and usually scaberulous ultimate branchlets, characterise this species.

5. A. LONGIFOLIA, E. Meyer in Drège, Zwei Pfl. Doc., 163 (1843).

A highly variable plant 1–2½ ft. high, entirely glabrous, with a slender terete stem usually leafy towards the base, more often subnude above, paniculately or corymbosely branched towards the apex; branches few, 2–3 in. long, ascending or spreading, usually bracteate and rigid. Leaves subcoriaceous, serrate-setose, the serratures distant or close, with setæ 1–4 lines long: radical few, spreading or ascending, shortly petiolate, 2½–6 in. long, ½–1 in. broad, narrowly oblong, lanceolate or oblanceolate, obtuse or rounded at the apex, tapering at the base; lower cauline leaves 3–4 in. long, amplexicaul, usually distant or rarely congested, adpressed, occasionally imbricate, with more coarsely serrated margins and longer setæ. Flower-heads few, ½–⅗ in. in diameter. Involucral segments 10, rigid, unequal or occasionally equal, acuminate, keeled. Calyx-teeth ⅓–½ line long, broadly ovate, subacute or mucronate, often papillate. Styles scarcely exceeding the calyx-teeth. Fruit entirely muricate or muricately ridged. Beauvard in Bull. Soc. Bot. Geneva III. iii. 134, t. 11 (1911).

South Africa. Strockenstroom Div.: In marshy places on the Kat Berg, 4,000–5,000 ft., *Drège!* Komgha: Between Zandplaat and Komgha, *Drège!* Griqualand East Div.: On the mountains near Clydesdale, *Tyson*, 2736 and 1277! Mount Frere, 4,300 ft. *Schlechter*, 6407! Pondoland: *Bachman*, 942! Zululand: *Gerrard*, 551! Natal, Drakensberg Range, *Rehmann*, 6971! Near Charlestown, 5,000–6,000 ft., *Wood*, 5615! Clairmont near Durban, 100 ft., *Wood*, 211! Near Durban, *Krauss*, 170! *Plant*, 7! *Sutherland!* Howick, *Junod!* Between Greytown and Newcastle, *Wilms*, 1995! Transvaal: In grassy places on the Houtbosch Range, 7,000 ft., *Schlechter*, 4724! Mountain-sides of the Saddleback Range near Barberton, 4,000–5,000 ft., *Galpin*, 818!

var. ANGUSTA, Dümmer, var. nov.

Folia radicalia 10–16, conferta, petiolata, petiolo angusto 2·5–10 cm. longo; lamina 5–15·2 cm. longa, 6–12 mm. lata, lanceolata vel lineare-lanceolata, apice obtusa vel acumi nata,basin versus in petiolam attenuata, margine obscure crenato-serrata, pilis 2–6 mm. longis.

Radical leaves 10–16, crowded, petiolate ; petiole 1–4 in. long, narrow ; blade 2–6 in. long, 3–6 lines broad, lanceolate to linear-lanceolate, acuminate to obtuse, tapering into the petiole below ; margin obscurely crenate-serrate, the awn-like bristles 1–3 lines long.

South Africa. Orange River Colony : *Cooper*, 3502 and 2542 ! Natal : Van Reenen, 5,000–6,000 ft., *Wood*, 5735 ! Noodsberg, 2,000–3,000 ft., *Wood*, 5215 ! Pietermaritzburg, *Wilms*, 1996 !

The long, narrow, crenate-serrate leaves distinguish the variety from the type.

6. A. PROPINQUA, Dümmer, sp. nov.

Planta circiter 4 dm. alta, glabra. Caulis erectus, basin versus angulatus, superne teres, foliatus sed aliquando subnudus, paniculato-ramosus, ramis plurimis gracillimis erecto-patentibus 5–20 cm. longis. Folia herbacea, utrinque obscure reticulata, margine minute vel grosse dentata; dentes in setis minutis 2–4 mm. longis producti; radicalia conferta vel pauca, laxe patentia, petiolata, petiolo 5 cm. longo, complanato; lamina 10–17 cm. longa, 2–3 cm. lata, spatulata, obovata vel oblonge-lanceolata, apice rotundata vel obtusa, basin versus paulo angustata; caulina remota, patentia vel ascendentia, vix amplexicaulia, oblonga vel aliquando subpanduriformia, sæpius hastata. Capitula plurima, ·8–1·2 cm. diametro. Involucri segmenta 5–10, patula, acuta vel acuminata, carinata, vix nervata. Calycis dentes 0·5 mm. longæ, acutæ vel mucronatæ. Fructus muricatus vel sæpe muricato-costatus.

Glabrous 1–3 ft. high. Stem erect, slender, angular at the base, terete above, leafy but occasionally subnude, paniculately branched from below the middle ; branches many, 2–10 in. long, very slender, erectly spreading. Leaves herbaceous, obscurely reticulated on both sides, margin minutely or coarsely triangularly toothed, with bristle-like points 1–2 lines long ; radical crowded or few, laxly spreading, petiolate; petiole 1–2 in. long, flattened ; blade 5–8 in. long, 1–1$\frac{1}{4}$ in. broad, spathulate, obovate-cuneate or oblong lanceolate, rounded or obtuse at the apex, tapering from near the middle to the base ; cauline distant, spreading or ascending, scarcely amplexicaul, oblong or occasionally slightly panduriform, subhastate at the base. Flower-heads usually many, $\frac{1}{3}$–$\frac{1}{2}$ in. in diam. Segments of the involucre 5–10, spreading, acute or acuminate, keeled, scarcely veined. Calyx-teeth $\frac{1}{4}$ line long, acute or mucronate. Fruit muricate or muricately ridged. *A. amatymbica*, Hiern in Oliv. Fl. Trop. Afr. III. 7, 1878 ; Engler in Pflanzenwelt Ost. Afr. C. 298, 1895 ; Beauvard in Bull. Soc. Geneva III. iii. 134, t. 11, 1911 ; Baker in Journ. Linn. Soc. Bot. XL. 75, 1911 (not Ecklon and Zeyher). *A. anatymbica*, Engler in Engl. and Drude's Veg. der Erde IX. 1, i. 372, t. 314, 1910.

Tropical Africa. British Central Africa, Nyassaland: Tanganyika Plateau, *Carson!* Kavirondo, 4,000–5,000 ft., *Scott-Eliott*, 7041! Shire Highlands, *Buchanan*, 16! *Adamson*, 12! Zomba, 2,000–6,000 ft., *Whyte*, 95! *Buchanan*, 802 and 683! *Purves*, 70! Near Lake Nyassa, *Simons!* Near Sochi and the Manganga Mountains, 3,000 ft., *Kirk!* Rhodesia: Chimanimani Mountains, 4,500 ft., *Johnson*, 194! *Swynnerton*, 6208 and 233! Near Chirinda, 3,500 ft., *Swynnerton*, 233!

The thinner, broader, distinctly dentate leaves and profusely branched inflorescences with slender lax branches usually suffice to distinguish this plant from its ally, *A. longifolia*, E. Mey., but the two species appear to insensibly pass into each other about the Tropic of Capricorn on the Houtbosch Range, and it may hereafter prove advisable to regard the tropical as a geographical form of the Natal species. The extremes are, however, so distinct that I have ventured on a separation; moreover, the petals of this are invariably shorter and narrower than the Natal species.

7. A. COARCTATA, Dümmer, sp. nov.

Glabra, circiter ·30 met. alta. Caulis erectus, teres, sulcatus, foliatus, superne racemoso-ramosus vel corymboso-ramosus, ramis rigidis paucis erecto-patentibus 2–2·5 cm. longis. Folia radicalia ignota; caulina subcoriacea, imbricata vel remota, amplexicaulia, adpressa vel adscendentia, infera 2·5–7·5 cm. longa, 1·2–2·5 cm. lata, anguste ovata, apice obtusa vel acuta, margine minute et creberrime serrato-ciliata vel dentato-serrata et ciliata, pilis 2–4 mm. longis. Capitula congesta, 1·8 cm. diametro, 12–15-flora. Involucri segmenta majora 5, aliquando minoribus alternans, coriacea, 6 mm. longa, 3–3·5 mm. lata, acuta vel apiculata, nervata. Calycis dentes subacutæ vel mucronatæ. Fructus ad apicem muricatus vel minute muricato-costatus. Carpophorum persistens.

A plant approximately 1 ft. high, glabrous. Stem erect, terete, sulcate, leafy, racemosely or corymbosely branched towards the apex, with rigid ascending, slightly spreading branches about 1 in. long. Radical leaves not seen; cauline imbricate or distant, subcoriaceous; amplexicaul, adpressed or ascending, the lower 1–3 in. long, $\frac{1}{2}$–1 in. broad, narrowly ovate, obtuse or acute at the apex, scarcely auriculate at the base, margin closely serrulate, ciliate or serrulate-denticulate-ciliate, with rigid hairs 1–2 lines long. Flower-heads many, congested, $\frac{3}{4}$ in. in diam., 12-15-flowered. Segments of the involucre 5, occasionally with smaller alternating; the larger 3 lin. long, $1\frac{1}{2}$–$1\frac{3}{4}$ lin. broad, acute or apiculate, nerved. Calyx-teeth subacute or mucronate. Fruit muricate at the apex or minutely muricately ridged. Carpophores persistent.

Tropical Africa. Nyassaland: Nyika Plateau, 6,000–7,000 ft. *Whyte* in *Herb. Kew* 156!

8. A. GRACILIS, Dümmer, sp. nov.

Planta glabra, 15–23 cm. alta, caule gracillimo folioso paucicephalo apicem versus racemoso-ramoso, ramis paucis 1·2–2·5 cm. longis. Folia leviter rigida, serrato-setosa: radicalia 5–10, rosulata, patentia vel ascendentia, petiolata vel subpetiolata; petiolum 6–9 mm. longum, complanatum vel sulcatum; lamina 2·5–4 cm. longa, 6–9 mm. lata, lineare-lanceolata vel anguste lanceolata, acuta vel obtusa basi sublonge cuneata, margine serrato-setosa, setis distantibus 2–6 mm. longis fuscis; caulina minora, amplexicaulia, remota vel imbricata, ascendentia. Capitula pauca, 8–12 mm. diametro; involucri segmenta 10, rigida, acuminata. Calycis dentes 0·7 mm. longæ. Fructus ignotus.

A glabrous herb, $\frac{1}{2}$–$\frac{3}{4}$ ft. high, with a slender leafy sparingly racemosely-branched stem; branches $\frac{1}{2}$–$\frac{3}{4}$ in. long, spreading or ascending. Leaves somewhat rigid, serrate-setose: radical 5–10, rosulate, spreading or ascending, petiolate or subpetiolate; petiole 3–9 lines long, flattened or grooved, dilated at the base; blade 1–1$\frac{3}{4}$ in. long, $\frac{1}{4}$–$\frac{1}{3}$ in. broad, linear-lanceolate or lanceolate, acute or obtuse, tapering to the base with the marginal setæ distant or close, 1–3 lines long; cauline imbricate or distant, adpressed or ascending, amplexicaul, acuminate. Flower-heads few, $\frac{1}{3}$–$\frac{1}{2}$ in. in diameter, with 10 narrow rigid acuminate involucral segments. Calyx-teeth $\frac{1}{3}$ line long. Fruit not seen.

South Africa. Delagoa Bay Region: Rocks of Marovougne, *Junod* in *Herb. Kew*, 922!

9. A. WOODII, Oliver, in Hook. Ic. Pl. 42, t. 1452 (1883).

Plant $\frac{3}{4}$–2 ft., entirely glabrous; stem stout or slender, divaricately branched, branching from below the middle; branches few or many, ascending, spreading. Radical leaves 8–10, rosulate, laxly spreading, petiolate; petiole $\frac{1}{2}$–3 in. long, 3 lines broad, usually clasping the stem throughout its entire length; blade 3–6 in. long, $\frac{1}{4}$–1$\frac{2}{3}$ in. broad, oblanceolate, oblong-spathulate to obovate-cuneate, obtuse or rounded at the apex, tapering from the middle to the base; margin coarsely dentate or serrate-setose with triangular stiff teeth; cauline leaves usually small, distant, adpressed or ascending, amplexicaul, auriculate, the lower ovate and acute. Flower-heads few, $\frac{1}{4}$–$\frac{1}{2}$ in. in diameter. Involucral segments 5–10, obtuse or subacute, scarcely keeled or veined. Calyx-teeth minute $\frac{1}{5}$ line long, obtuse. Styles short, stout, truncate. Fruit muricate or muricately ridged.

South Africa. Natal: Near Byrne, 3,000 ft., *Wood*, 1845! Cedara, *Wylie* in Natal Government Herb., 12153!

10. A. Tysonii, Dümmer, sp. nov.

Glabra; caulis a 4 dm. altus, gracilis, subnudus, laxe racemoso vel paniculato-ramosus, ramis paucis gracilibus nudis laxisque 7·5–12·7 cm. longis. Folia leviter chartacea sed rigida, subtus prominule venosa, dentata, dentibus angustis creberrimis rigidis 1–2 mm. longis fuscis; radicalia 5–7, rosulata, erecta, petiolata vel subpetiolata, petiolo 8–24 mm. longo complanato; lamina 4–6·5 cm. longa, 1·2–2·5 cm. lata, anguste obovata-cuneata, apice rotundata apiculataque, basi angustata; caulina pauca, amplexicaulia, adpressa, parva sed aliquando paucis foliis majoribus basin versus. Capitula a 8 mm. diametro. Involucri segmenta 10, inæqualia, patula, papyracea, apiculata, carinata, majoribus 2 mm. latis.

Glabrous; stem about 2 ft. high, slender, subnude, laxly racemosely or paniculately branched; branches few, slender and lax, nude, 3–5 in. long. Leaves more or less papery but rigid, with the nerves prominent on the lower side, closely dentate; teeth narrow, rigid, $\frac{1}{2}$–1 line long. Radical 5–7, rosulate, erect, petiolate or subpetiolate; petiole $\frac{1}{3}$–1 in. long, flattened; blade $1\frac{1}{2}$–$2\frac{1}{2}$ in. long, $\frac{3}{4}$–1 in. broad, narrowly obovate-cuneate, rounded or apiculate, tapering to the base; cauline few, amplexicaul, adpressed, acute, the lower occasionally large and narrowly oblong with longer teeth. Flower-heads few, about $\frac{1}{3}$ in. in diam. Involucral segments 10, unequal, spreading, papery apiculate, keeled; the 5 larger 1–$1\frac{1}{2}$ lin. long, 1 lin. broad. Calyx-teeth minute, acute. Fruit muricately ridged.

South Africa. Griqualand East Div.: On stony slopes about Kokstad, 4,300–4,500 ft., *Tyson*, 1465! and in Herb. Austr.-Afr., 1275!

Allied to *A. Woodii*, Oliv., from which it differs in the laxly branched inflorescence, the narrow marginal teeth of the leaves, papery apiculate involucral segments and acute calyx-teeth. I have pleasure in associating this species with Mr. W. Tyson, an eminent South African plant collector and algologist.

11. A. ciliaris, Delaroche, Eryng. Hist. 19, t. 1 (1808).

Glabrous, $\frac{3}{4}$–$1\frac{1}{2}$ ft. high. Stem slender, subnude, terete, and grooved, racemosely or paniculately branched;* branches slender, ascending, spreading, 1–5 in. in length. Radical leaves petiolate, seldom many, rosulate, subcoriaceous, ascending or spreading; petiole 1–$3\frac{1}{2}$ in. long, slender, terete, grooved; blade 1–2 in. long, $\frac{1}{4}$–1 in. broad, oblong to oblanceolate or narrowly ovate, rounded, obtuse or apiculate, obliquely rounded or cordate at the base, coarsely dentate, crenate-dentate or rarely dentate-serrate with two series of bristles, one series terminating the teeth, the other series alternating with them, and often inflexed upon the

* In robust plants the stem may branch from near the base.

upper surface; cauline leaves usually inconspicuous, lanceolate, amplexicaul, adpressed or slightly spreading, acute. Flower-heads usually few, $\frac{1}{4}$–$\frac{1}{2}$ in. in diam. Segments of the involucre 10, unequal, acute, keeled. Calyx-teeth $\frac{1}{3}$ line long and about as broad, mucronate or apiculate. Fruit densely muricate. Poiret in Lam. Encyl. Supp. I. 288, 1810. Trattinnick Gen. Nov. Pl. 9, t. 49, 1825. DC. Prod. IV. i. 87, 1830. Don. Syst. Bot. III. 266, 1834. Dietrich Syn. Pl. II. 935, 1840. Sond. in Fl. Cap. II. 534, 1862, excl. syn. Var. *a*, Sonder, *l.c.*

Alepidea cillaris, Steud. Nom. 26, 1821. *Alepida ciliaris*, Kuntz. Rev. Gen. III. ii. 111, 1898. *Astrantia ciliaris*, Schult. Syst. Veg. VI. 344, 1820.

South Africa. George Div.: Moist lands near George, *Bowie!* Albert Div.: *Cooper*, 680 partly! Graaff Reinet, Koudeveldt, 4,000–5,000 ft., *Tyson!* Transvaal: Caledon River, *Nelson*, 8! Natal: Weenen, 4,800 ft. *Wood*, 6644! Near Nottingham Road, *Wood*, 5234! Same locality, *Wood* in Natal Gov. Herb., 7611! Without locality; *Masson! Forster!* and a specimen in Herb. Linnæus!

Dr. B. D. Jackson, of the Linnæan Society, courteously permitted me to examine the specimens in the Linnæan Herbarium, of which there are two affixed to one sheet. The one marked T 374 represents the allied species *A. serrata*, Ecklon and Zeyher, though both are labelled *Astrantia ciliaris.* From the description of that species, I infer that Linnæus based it upon the numbered specimen.

12. A. SERRATA, Eckl. and Zey., Enum. Pl. 339 (1835).

Glabrous, $\frac{1}{2}$–$1\frac{1}{2}$ ft. high; stem slender, subnude, racemosely or paniculately branched, the branches slender and ascending, 1–6 in. long. Radical leaves 4–14, rosulate, erect or spreading, petiolate; petiole $\frac{1}{2}$–3 in. long, slender, terete, and grooved, or slightly flattened; blade 2–6 in. long, $\frac{1}{4}$–$\frac{1}{2}$ in. broad, lanceolate, linear-lanceolate, or rarely oblanceolate, coriaceous or subcoriaceous, occasionally reticulated on both sides, obtuse, acute or acuminate, tapering or slightly rounded at the base, with coarsely serrate-setose or double-serrate (rarely crenate-serrate), margin, with rigid setæ between the teeth, which are usually inflexed and appressed to the upper surface. Stem-leaves inconspicuous, remote, adpressed or ascending, amplexicaul, acute. Flower-heads usually few, $\frac{1}{3}$–$\frac{1}{2}$ in. diam. Calyx-teeth $\frac{1}{3}$ line long, mucronate. Styles stout, obtuse. Fruit compressed, muricately ridged, or entirely muricate. Dietrich Syn. Pl. II. 935, 1840. Walp. Repert. II. 388, 1843. *Alepidea ferrata*, Steud. Nom. 48, 1840. *Alepidea serrata*, *A. moltenensis* and *A. cathcartensis*, O. Kuntze, Rev. Gen. III. ii. 111, 1898. *Astrantia ciliaris*, Linn. f. Supp. 177, 1871. Linn., Syst. Veg. 273, 1784. Thunb. Prod. 49, 1794.

Willd., Sp. Pl. I. ii. 1369, 1797. Persoon, Syn. Pl. I. 304, 1805. Thunb. Fl. Cap., II. 196, 1818. *Jasione capensis*, Berg. Act. Ups. III. 188, t. x. 1780.

South Africa. Fort Beaufort Div.: Katriver and the Winterberg, *Ecklon*, 2188! Stockenstroom Div.: Katberg, 4,000–5,000 ft., *Drège*, partly! Cathcart Div.: Mountains above Toise River Station, 3,000 ft., *Flanagan*, 2292! Albert Div.: *Cooper*, 680, partly! Kraffraria: Near Dohne, *Flanagan*, 2292! Tembuland: Along the river near Engcobo, 3,850 ft., *Bolus*, 10,098! Griqualand East: Matatiele, 5,000 ft. *Tyson*, 1618! In Herb. Linnæus, T 374, without locality, partly!

The linear, lanceolate, serrate leaves with the alternating inflexed bristles usually serve to distinguish this species from *A. ciliaris*, Delaroche, with which it was formerly confounded.

13. A. CORDATA, E. Mey. in Drège Zwei Pflanz. Doc. 163, 1843 (partly).

A glabrous plant $\frac{3}{4}$–$1\frac{1}{2}$ ft. high. Stem slender, more or less leafless, sparely paniculately branched; branches few, slender, ascending 2–6 in. long. Radical leaves 5–8, rosulate, spreading or ascending, coriaceous, petiolate; petiole 1–5 in. long, slender, terete, grooved, slightly winged at the base; blade 1–3 in. long, $\frac{1}{3}$–$1\frac{1}{6}$ in. broad, oblong to broadly oblong, rounded at the apex, cordate or rounded at the base with dentate margin; teeth (in dried specimens) keeled above and prolonged into a stout rigid bristle, $\frac{1}{6}$–$\frac{1}{4}$ in. long, often inflexed or directed downwards; no bristles between the teeth. Cauline leaves inconspicuous, few, adpressed or ascending, acute to acuminate. Flower-heads few, $\frac{1}{3}$–$\frac{1}{2}$ in. diam. Involucre segments varying in number and size, rigid, acute or obtuse, keeled. Calyx-teeth $\frac{1}{2}$ lin. long, broadly ovate, mucronate, or acute. Styles truncate or slightly capitate. Fruit densely muricate. *A. ciliaris*, Eckl. and Zey. Enum. Pl. 339, 1835. Walp. Repert. II. 388, 1843 (not Delaroche). *A. ciliaris*, var. *latifolia*, Eckl. and Zey. *loc. cit.* var. *b*, Sonder in Fl. Cap. II. 534, 1862. *Alepida cordata*, O. Kuntze, Rev. Gen. Pl. III. ii. 111, 1898.

South Africa. Albany Div.: Witteberg Range, 7,000–8,000 ft. *Drège* partly! Soutar's Post, near Tea Fontein, *Burchell*, 3477 and 3477 B! Swellendam Div.: Near Swellendam, *Bunbury!* Uitenhage Div.: near Uitenhage, *Burchell*, 4461 B and 4582! *Zeyher*, 700! Port Elizabeth Div.: near Port Elizabeth, Miss Ethel *West!* Humansdorp Div.: near Krumrivier, *Ecklon*, 2187! *Bowie*, 142! and *Drège* 22! without locality.

This species has hitherto been confounded with *A. ciliaris*, Delaroche, but the terete slender petioles, coriaceous leaves with stout bristles, and the absence of the latter from between the keeled triangular teeth, constitute important points of distinction.

14. A. Galpinii, Dümmer, sp. nov.

Planta gracilis, circiter 17·5 cm. alta, caule subnudo racemoso-ramoso vel corymboso-ramoso, ramis ascendentibus 2·5–5 cm. longis bibracteatis. Folia radicalia 6, petiolata, petiolo 2·5–3·5 cm. longo; lamina 1·2–2·5 cm. longa, 8–12 mm. lata, oblonga vel elliptica, apice obtusa vel apiculata, basi oblique cordata vel rotundata, margine crenato-dentato-setosa, setis remotis vix 2 mm. longis; caulina pauca, parva, ascendentia vel adpressa. Capitula 8–12 mm. diametro, 10–13 flora. Involucri segmenta 10, inæqualia, rigida, acuminata, nervata. Calycis dentes vix ullæ. Fructus valde muricatus.

A slender plant about 7 in. high, entirely glabrous, with a subnude, terete, and obscurely grooved stem, racemosely or corymbosely branched above; branches 1–2 in. long, bibracteate. Radical leaves 6, ascending, thin, dull green, petiolate; petiole 1–1½ in. long, slender, grooved; blade ½–1 in. long, ⅓–½ in. broad, oblong-elliptic, obtuse and apiculate, obliquely cordate or rounded at the base; margin crenate-dentate, with the teeth tipped by awns, often recurved, scarcely exceeding a line long; cauline leaves few, linear or lanceolate, ascending and adpressed. Flower-heads few, ⅓–½ in. in diam., 11–13 flowered. Segments of the involucre 10, unequal, rigid, acuminate, keeled, with cartilaginous margins, the larger 1½ lines long. Calyx-teeth rudimentary, deltoid. Fruit densely muricate.

South Africa. Barkly East Div.: Witteberg Range; on damp slopes of Ben MacDhui, 9,200 ft. *Herb. Galpin*, and *Natal*, 6638!

15. A. Swynnertonii, Dümmer, sp. nov.

Herba gracilis, glabra, a 30 cm. alta, caule erecto tenue subnudo basin versus angulato racemoso-ramoso, ramis paucis 2·5–4 cm. longis erecto-patentibus remotis. Folia radicalia rosulata, patentia, petiolata; petiolum 6–18 mm. longum; lamina 5–6 cm. longa, 12–18 mm. lata, oblonga, obovata, apice obtusa vel rotundata, basi rotundata, subcoriacea, margine obscure vel grosse serrato-setosa; folia caulina pauca, inconspicua, adpressa, auriculata, acuta. Capitula 8 mm. diametro. Involucri segmenta 10, æqualia, acuta, nervata, coriacea. Calycis dentes 0·7 mm. longæ, late ovatæ, apiculatæ, subpapillatæ. Ovarium subcompressum. Fructus maturus ignotus.

A slender, glabrous herb approximately a foot high, with an erect, subnude, racemosely branched stem, somewhat angular at the base, terete above; branches ascending, 1–1½ in. long. Radical leaves, 6–7, rosulate, spreading, petiolate, subcoriaceous; petiole ¼–¾ in. long, flattened; blade 2–2½ in. long, ½–¾ in. broad, oblong or obovate, obtuse or rounded at both ends; margin obscurely or coarsely serrate-setose, the setæ rigid, 1–2 lines long; stem-leaves few, inconspicuous, distant, adpressed, acute, and auricled. Flower-heads scanty, about $\frac{1}{3}$ in. in diameter. Involucre of 10 equal acute nervate segments. Calyx-teeth $\frac{1}{3}$ line long, broadly ovate, apiculate, slightly papillate. Ovary subcompressed. Mature fruit not seen.

Tropical Africa. Rhodesia: Common in short grass on the Chimanimani Mountains, 7,000 ft. *Swynnerton* in *Herb. Brit. Mus.* 6208*a* !

16. A. comosa, Dümmer, sp. nov.

Planta glabra, circiter 30 cm. alta; caulis subnudus, e basi angulatus, apicem versus teres et paniculato-vel corymboso-ramosus, ramis paucis ascendentibus 2·5 cm. 7·5 cm. longis. Folia rigida, erecta, coriacea, marginibus serrato-setosis, setis rigidis remotis; radicalia, 10–15, conferta, petiolata; petioli 1·2–2·5 cm. longi, complanati vel sulcati; lamina 2·5–6 cm. longa, 6–8 mm. lata, lineari-lanceolata, acuta, basi angustata, setis marginalibus, 4–6 mm. longis; caulina minora, pauca, remota, adpressa, amplexicaulia, acuminata. Capitula pauca, 1·2 cm. diametro, plus minusve congesta. Involucri segmenta 10, rigida, acuta, carinata nervataque, marginibus scariosis, segmenta majora 2·5 mm. lata. Calycis dentes subacutæ, 1 mm. longæ. Fructus ignotus.

Plant glabrous, about 1 ft. high; stem subnude, angular at the base, terete and paniculately or corymbosely branched above; branches few, slender, ascending, 1–3 in. long. Leaves rigid, erect, coriaceous, reticulate on both sides, serrate-setose, the setæ stiff. Radical leaves 10–15, tufted, petiolate; petiole $\frac{1}{2}$–1 in. long, flattened or grooved; blade 1–2$\frac{1}{2}$ in. long, 3–4 lines broad, linear-lanceolate, acute, tapering from below the middle to the base; the marginal setæ remote, 4–6 mm. long; cauline leaves few, small, amplexicaul, adpressed, acuminate. Flower-heads few, 1·2 cm. in diam., more or less congested. Segments of the involucre 10, unequal in size, rigid, acute keeled and nerved, with scarious margins; the larger 1$\frac{1}{4}$ lines broad. Calyx-teeth $\frac{1}{2}$ line long, subacute. Fruit not seen.

South Africa. Transvaal: Modderfontein, *Conrath* in *Herb. Kew*, 321 !

The tufted, erect, lanceolate, coarsely serrate leaves, few flower-heads, scariously margined involucral segments, characterise this species.

17. A. longeciliata, Schinz, MS.

Glabrous, $\frac{3}{4}$ ft. high. Stem stout, terete, grooved, racemosely branched; branches slender, ascending, 1$\frac{1}{2}$–3 in. long. Radical leaves approximately 9, rosulate, spreading, petiolate, coriaceous, obscurely reticulate; petiole $\frac{3}{4}$–1 in. long, 2–3 lines broad, slightly winged and carinate; blade, 1–1$\frac{1}{2}$ in. long, $\frac{1}{2}$–1 in. broad; obovate, spathulate or rotund, occasionally narrowing into the petiole, margin denticulate, ciliate with stout rigid crowded bristles, 1–3 lines long, pale ochre or ashy grey. Stem-leaves inconspicuous, remote, adpressed, amplexicaul, slightly auriculate, acuminate. Flower-heads large, $\frac{1}{2}$–$\frac{3}{4}$ in. in diam., 12–14 flowered. Segments of the involucre 10, equal, broad, cuspidate, keeled and veined. Calyx-teeth broad, mucronate. Fruit muricate.

South Africa. Transvaal: between Middleburg and the Crocodile River. *Wilms* in *Herb. Kew*, 567 !

18. A. Wyliei, Dümmer, sp. nov.

Glabra, circiter 40–45 cm. alta; caulis tenuis, subnudus, apicem versus corymboso-vel paniculato-ramosus, ramis paucis patentibus aut ascendentibus 5–7·5 cm. longis. Folia coriacea, serrata vel crenato-serrata setosa, setis rigidis: radicalia 4–6, rosulata, patentia, petiolata; petioli 6–12 mm. longi, complanati vel sulcati; lamina 5–7·5 cm. longa, 1·8–2·5 cm. lata, ovata vel obovata, utrinque rotundata, setis marginalibus remotis 4–6 mm. longis. Folia caulina minora, 1·2–2·5 cm. longa, amplexicaulia, remota, adpressa. Capitula pauca, 1·2–1·8 cm. diametre, 10–14-flora. Involucri segmenta 10, subæqualia, rigida, acuta, exteriora pallide-lilacina. Calycis dentes 0·5 mm. longæ. Fructus muricatus.

Plant 1$\frac{1}{4}$–1$\frac{1}{2}$ ft. high, glabrous. Stem slender, subnude, corymbosely or paniculately branched towards the apex; branches few, 2–3 in. long stiffly ascending and spreading. Leaves coriaceous, obscurely reticulated on both surfaces, serrate or crenate-serrate setose, serrations distant: radical 4–6, rosulate, patent, petiolate; petiole $\frac{1}{4}$–$\frac{1}{2}$ in. long, flattened; blade 2–3 in. long, $\frac{3}{4}$–1 in. broad, ovate or obovate, rounded or obtuse at the apex, rounded at the base. Cauline small, $\frac{1}{2}$–1 in. long, 2–4 lines broad; amplexicaul remote or occasionally imbricate, adpressed, acuminate. Flower-heads few, $\frac{1}{2}$–$\frac{3}{4}$ in. diam., 10–14 flowered, borne on slender but rigid bracteate stalks 1–2 in. long. Segments of the involucre 10, the alternate segments smaller, rigid, spreading, acute, externally pale-lilac in colour. Calyx-teeth $\frac{1}{4}$ line long. Styles truncate. Fruit muricate.

South Africa. Zululand: 4,000–5,000 ft., *Wylie* in *Herb. Wood* and *Kew*, 9015 !

19. Alepidea (by error Alepida) Baurii, O. Kuntze Rev. Gen. III. ii. 110 (1898).

A glabrous plant 1–1$\frac{3}{4}$ ft. high. Stem subnude, slender, terete, grooved, racemosely or paniculately branched; branches usually ebracteate, few, distant, ascending, slender, 2–4 in. long. Radical leaves 4–8, rosulate, spreading, petiolate or subpetiolate, somewhat herbaceous; petiole $\frac{1}{4}$–$\frac{3}{4}$ in. long, membranous and partly ciliate; blade 2–3$\frac{1}{2}$ in. long, $\frac{1}{4}$–$\frac{3}{4}$ in. broad, elliptic, ovate-lanceolate or oblanceolate, rounded, obtuse, or apiculate, tapering to the base; margin entire or obscurely denticulate, ciliate, the hairs distant or close, unequal, 1–3 lines long, light brown; cauline leaves inconspicuous, few, distant, adpressed, amplexicaul, acute, the upper bracteal leaves laciniate. Flower-heads few. Involucre of 5 subequal segments, 2 lines long, 1 line broad, rarely with alternating smaller segments, obtuse or apiculate, nerved. Calyx-teeth narrow, $\frac{1}{3}$ line long. Fruit with muricate ribs.

South Africa. Tembuland: Bazeia, 2,500 ft., *Baur*, 116! Natal: Inanda, *Wood*, 251 partly! Amawahgua Mountain, 6,000–7,000 ft., *Wood*, 4587!

Wood's specimens from the Amawahgua Mountain are exceedingly small, the smallest scarcely measuring $1\frac{1}{2}$ inches, and thus present a distinct appearance. Despite this, I can only regard them as environmental forms of the above, as in their floral characters they appear to be identical.

Var. LANCEOLATA, Dümmer, comb. nov.

Radical leaves 6–10, petiolate; petiole 1–3 in. long, flattened, irregularly ciliate; blade 2–6 in. long, $\frac{1}{2}$–1 in. broad, lanceolate or oblanceolate-cuneate, obtuse, narrowing to the base, obscurely denticulate, irregularly ciliate, with hairs 2–3 lines long, pale brown. Segments of the involucre 5, $2\frac{1}{2}$ lines long, $1\frac{1}{4}$ lines broad, acute or obtuse. *Alepida lanceolata*, O. Kuntze Rev. Gen. III. ii. 111 (1898).

South Africa. Griqualand East: On the slopes of Mount Currie, 5,000 ft., *Tyson* in *Herb. Kew*, 1375!

The longer petiolate leaves distinguish the variety from the type.

20. A. NATALENSIS, Wood and Evans in Jour. Bot. 255 (1899).

Glabrous, 5–14 in. high. Stem slender, subnude, sparsely or profusely racemosely branched, the branches ascending and spreading, 1–3 in. long. Leaves coriaceous, conspicuously veined beneath, margin serrulate-setose or denticulate, ciliate: radical 4–10, rosulate, more or less spreading, petiolate or subpetiolate; petiole $\frac{1}{4}$–1 in. long, flattened with ciliate edges; blade $\frac{3}{4}$–2 in. long, 5–12 lines broad, obovate-cuneate or oblanceolate-cuneate, rounded or obtuse at the apex, tapering to the base; cilia rigid, $\frac{1}{2}$–3 lines long; cauline obsolete, distant, amplexicaul, adpressed. Flower-heads few or rarely many, 10–14 flowered, $\frac{1}{3}$–$\frac{1}{2}$ in. in diameter. Involucral segments usually 5, large, equal, coriaceous, obtuse or acute, often coloured deep red within. Calyx-teeth $\frac{1}{2}$–$\frac{1}{2}$ line long, subulate. Fruit entirely muricate or tuberculate at the apex.

South Africa. Pondoland: Faku's Territory, *Sutherland!* Natal: Mount Gilboa, 3,000–4,000 ft., *Wylie* in Herb. Wood, 6243! Orange River Colony: Harrismith, 7,000 ft., *Sankey*, 62!

21. A. CONCINNA, Dümmer, sp. nov.

Planta omnino glabra, 15–30 cm. alta, paucicephala; caulis tenuis, apicem versus racemoso-ramosus, ramis brevibus ascendentibus 1·2–2·5 cm. longis. Folia papyracea, utrinque obscure reticulata, margine integra vel minute denticulata, ciliata: radicalia 5–12, rosulata, patentia, subpetiolata; lamina 2·5–4 cm. longa, 6–18 mm. lata, elliptica vel obovato-cuneata, apice rotundata vel obtusa, dense ciliata, pilis 4–10 mm. longis fuscis; caulina imbricata, inconspicua, ascendentia, adpressa, amplexicaulia subauriculataque, acuminata, setis longioribus. Capitula 12-flora, 6–8 mm. diametro. Calycis dentes 0·3 mm. longæ, acutæ. Styli 0·8–0·3 mm. longi. Fructus ignotus.

Plant glabrous in all parts, $\frac{1}{2}$–1 ft. high; stem slender, racemosely branched towards the top; branches short, ascending $\frac{1}{2}$–1 in. long. Leaves more or less papery, entire or minutely denticulate, densely ciliate: Radical leaves 5–12, rosulate, patent, subpetiolate; blade 1–1$\frac{3}{4}$ in. long, 3–6 lines broad, elliptic or cuneate-obovate, apex obtuse or rounded, cilia unequal, close, 2–6 lines long, dark brown; cauline adpressed, imbricate or distant, amplexicaul, slightly auriculate, acuminate with long prominent marginal bristles, the bracteal leaves more or less laciniately bristled. Flower-heads few, 12-flowered, $\frac{1}{4}$–$\frac{1}{3}$ in. in diameter. Involucral segments usually 5. Calyx-teeth $\frac{1}{7}$–$\frac{1}{5}$ line long, acute. Styles $\frac{1}{3}$–$\frac{1}{2}$ line long. Fruit not seen.

South Africa. Natal: Inanda, *Wood* in *Herb. Kew*, 251 partly!

This species approximates most closely to *A. natalensis*, Wood and Evans, from which, however, it differs in the smaller, more compact inflorescence, the entire densely ciliate leaves, and minute calyx-teeth.

22. A. PEDUNCULARIS, Steud. Pl. Schimp. Abyss. II. 559 (1842).

Plant $\frac{1}{2}$–3 ft. high, entirely glabrous, with a slender or lax stem, slightly angular below, terete and grooved above, leafy, corymbosely branched; branches $\frac{1}{2}$–2 in. long, spreading, slender but rigid. Leaves thin, pale green, crenate-dentate or crenate-serrate, teeth tipped with fine awn-like points 1–3 lines long; radical laxly spreading, petiolate; petiole 1–4 in. long, flattened, and membranous; blade 6–9 in. long, $\frac{3}{4}$–1 in. broad, narrowly oblong, rounded or obtuse at the apex, tapering or rounded at the base; cauline imbricate or distant, ascending or spreading amplexicaul, broadly auricled, but scarcely clasping, oblong, rounded, acute or acuminate at the apex. Flower-heads few, large, $\frac{3}{4}$ or exceeding 1 in. in diameter, 10–15-flowered. Involucral segments subcoriaceous, varying in number and size, the larger 5 lines long, 1 line broad, acuminate and prominently nervate. Calyx-teeth large, $\frac{1}{3}$ line long, broadly ovate, mucronate or acute. Styles capitate or truncate. Fruit compressed, muricately ridged. Steud. in Rich. Fl. Abyss. II. 320, 1847. Walp. Ann. II. 694, 1852; Hiern in Oliv. Fl. Trop. Afr. III. 7, 1877. Engler Hochgebirgsfl. Trop. Afr. 316, 1892; in Engler and Drude, Veg. der Erde IX. 1, i. 106, t. 88, 1910.

Tropical Africa. Nile Land, Abyssinia. *Schimper* 7 and 1241! Near Endschedcap towards Schoata, *Schimper*, 559! On Mount Aber near Dschenausa, *Schimper*, 848!

Var. *Fischeri*, Engler Hochgebirgsfl. Trop. Afr., 316, 1892, is said to differ from the type in the shorter involucral segments. Engler in Pflanz. Ost Afr. C. 298, 1895.

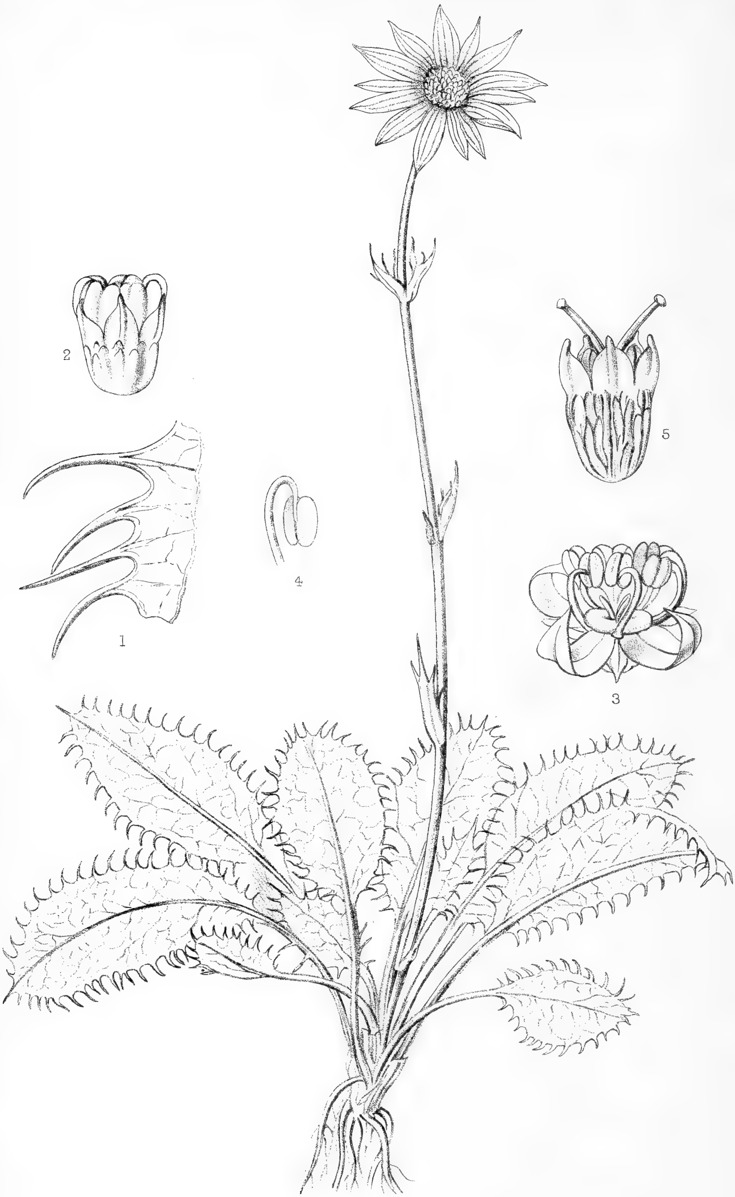
Tropical Africa. Masai Highlands, Ukira, Victoria Nyanza, Fischer, 280.

I have not seen this variety.

23. A. Thodei, Dümmer, sp. nov.

Herba pusilla, glaberrima, 10–20 cm., alta, caule subnudo 1–3-cephalo. Folia radicalia 4–8, subpetiolata vel petiolata, petiolo 3·5 cm. longo; lamina 2·5–6 cm. longa, 1·2–1·8 cm. lata, ovata, obovata vel elliptica, obtusa, apiculata, basi leviter oblique rotundata vel subattenuata, chartacea, margine dentata vel serrato-setosa, setis rigidis 4–6 mm. longis sæpe decurvatis. Capitulum 15–30-florum. Involucrum magnum, 1·8–3 cm. diametro, segmentis 11–15 patulis inæqualibus a medio connatis obtusis vel acutis integris. Calycis dentes 0·5 mm. longæ, subacutæ. Fructus immaturus, subcompressus, apice vel toto muricatus.

Plant dwarf, 4–8 in. high, glabrous; stem subnude, terete or slightly angular, bearing a solitary terminal large flower-head or occasionally three, the two lower smaller and opposite; lateral peduncles 1–1½ in. long. Radical leaves 4–8, suberect or spreading, thin in texture and reticulate on both sides, petiolate or subpetiolate; ¾–1½ in. long, membranous, usually channelled; blade 1–2½ in. long, ½–¾ in. broad, ovate, obovate to elliptic, obtuse, apiculate, subobliquely rounded or tapering to the base; margin dentate or serrate-setose with the teeth keeled and the setæ 2–3 lines long, rigid and often recurved; cauline few, distant, ascending or adpressed acuminate and coarsely toothed, the uppermost opposite, connate, subtending the lower branches of the inflorescence. Flower-heads 15–30-flowered, flowers purplish. Involucre large, when expanded ¾–1¼ in. across; segments 11–15, united at their middle, unequal, spreading, obtuse to acute, entire with subparallel veins, greenish without, pale ochre within, larger segments 5–6 lines long, 1–3 lines broad. Calyx-teeth ½ mm. long, subacute. Immature fruit subcompressed, muricate all over or only on the ridges or at the apex. *Alepidea*, sp., Wood,



M. Smith del. West, Newman lith.

ALEPIDEA THODEI, *Dümmer*.

Handb. Fl. Natal, 57 (1907); in Trans. South Afr. Phil. Soc., XVIII. pt. 2, 161 (1908).

South Africa. Barkly East Div.: Mountain-sides Doodman's Krans and Ben MacDhui, 8,800–9,900 ft. *Galpin*, 6540! Natal: Mont aux Sources, Drakensberg, *Thode* in Natal Government Herb., 10770!

This interesting and distinct species approximates most closely to the Abyssinian *A. peduncularis*, Steud., in its large flower-heads, but their paucity combined with their relative size and other morphological differences render the plant easy of identification.

PLATE I.

FIG. 1, edge of leaf; 2 and 3, ♂ flowers; 4, stamen; 5, ♀ flower with petals removed.

POSITIVE ELECTRICAL VARIATION IN ISOLATED NERVE.

By W. A. Jolly.

(Received May 15, 1912.)

(With Five Text-figures.)

The electrical changes which occur in living tissue form a valuable part of our data in the investigation of vital processes. In living nerve the difficulty of demonstrating any change of form, chemical change or evolution of heat, or distinct histological modification accompanying activity renders the study of the electrical changes especially important.

These changes in nerve are various. Some are clearly dependent on its physical properties of electrolytic conduction and polarisation, others must be ascribed to its special activities as living tissue. Wide generalisations regarding the anabolism and katabolism of all living tissues are to a considerable extent based upon the changes of opposite sign which occur in nerve.

The literature on the subject is very extensive, and many different instruments and methods of investigation have been employed.

It is no easy matter to correlate the results obtained by different observers in this branch of research and to interpret them in the light of later work.

The following contribution to the subject forms a sequel to work undertaken in the Physiological Laboratory of Edinburgh University, the results of which were communicated to the Physiological Society of England.

When a nerve isolated from the body is stimulated by the faradic current it was shown by Hering* that at the close of the stimulation an electrical variation appears which deflects a galvanometer in the same direction as the demarcation current of the nerve, that is to say, there is a positive variation.

* Beitr. z. allgem. Muskel u. Nervenphysiologie. 15 Mitt. Sitzungsber. d. Wiener Akad. Bd. 89. 3 Abt. 1884.

During stimulation the moving part of the instrument is deflected in the opposite direction to the demarcation current, and this constitutes the negative variation.

A negative variation accompanies activity of living nerve, and when the leading off electrodes are applied to a nerve dissected out from the body of a newly killed frog, one on the uninjured longitudinal surface and the other on the cross-section, the instrument is deflected under the influence of the action current developed at the electrode on the uninjured spot. The changes giving rise to action current do not, in consequence of the injury, occur at the cross-section, or only to a slight extent.

The positive after-variation was regarded by Hering and also by Head,* who later investigated the phenomenon, as occurring in the neighbourhood of the electrode upon the longitudinal surface, and was attributed to a process occurring in the nerve opposed to that process which may be termed excitation.

According to Hering's conception, stimulation of a nerve produces phasic upward and downward changes, and at the close of a period of stimulation the positive variation which occurs evidences a process of building up or assimilation, a restitution process in the nerve which follows its period of activity.

Head discussed the possibility that the occurrences giving rise to the positive change are located at the cross-section. The appearance of positive change would be presented if the cross-section of the nerve were to become more negative to the longitudinal surface than before stimulation, that is to say, if the demarcation current were increased by the tetanisation. Head came to the conclusion that it is more probable that the process is localised not at the cross-section but at the longitudinal surface, and agrees with Hering that it accompanies a process of restitution.

Waller† found that where the nerve has been preserved for several hours before stimulation, in place of the usual negative variation accompanying activity, a positive variation may be obtained. In explanation of this reversal Waller suggests several possibilities. (1) It may be due to a reversal of action (or of greater action) in the parts of the nerve at and near the two leading-off electrodes. Since the normal negative deflection is due to action predominant near the electrode on the longitudinal surface of the nerve, the positive deflection now obtained might depend upon action becoming predominant at the cross section in consequence of some accidental and progressive injury near the longitudinal lead off. (2) The positive deflection may be a phenomenon of the same order as the positive after-variation described by Hering. (3) The reversal may be due

* Pflüger's Arch. Bd. 40 S. 207, 1887.

† Phil. Trans. London, 1896.

to electrotonic changes produced in the nerve by the stimulating current. Waller took the view that the second of these possibilities is the more probable.

Since the invention by Einthoven of the string galvanometer, this instrument has been employed in the investigation of the electrical changes in nerve.

Fig. 1 shows the negative variation produced by a period of tetanisation of 30 sec., followed by the positive after-variation. The leading off non-polarisable electrodes have been placed in my experiments, one on the

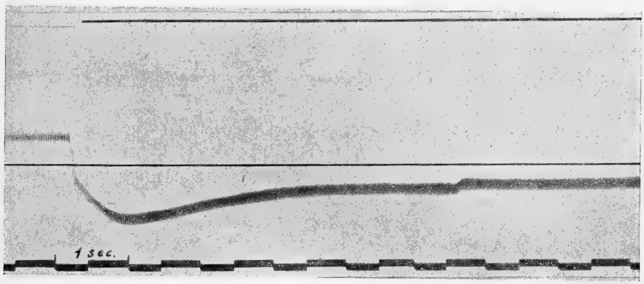


Fig. 1.

Response obtained from freshly isolated sciatic nerves of frog after tetanisation for 30 sec. Non-polarisable electrodes applied to longitudinal surface and cross-section, 1 cm. between electrodes. Resistance of preparation and electrodes = 25,000 Ohms. Upper line = signal indicating cessation of tetanisation. Zero line is marked by shadow of bristle. A control curve is given, representing the introduction into galvanometer circuit of a potential difference of 10^{-4} Volts. Lowest line = time marker indicating seconds.

The record, which reads from left to right, shows (1) the termination of an upward deflection, the negative variation or action current, upon which are superposed the individual responses to the induction shocks, (2) a downward deflection, the positive after-variation, and (3) persisting positive change.

longitudinal surface of the nerve and the other on the cross-section. The stimulating electrodes are of platinum and lie at the central end of the nerve. They are of the form recommended by Engelmann. Where localised cooling has been used the nerve between the leading-off electrodes is passed through a slit in a cardboard screen and the slit is closed by moist kaolin clay. The nerve and electrodes are enclosed in a moist chamber.

Like Waller, I have found that the electrical variation accompanying activity may be reversed, and this is so especially if the nerves have been preserved for a considerable time before experiment.

Fig. 2 gives an example of this obtained from a nerve sixteen hours after preparation.

Garten* has shown that in experiments in which the leading-off electrodes are applied to two points on the uninjured longitudinal surface the action current may present itself, when the distal electrode is cooled, as a deflection of the galvanometer which would appear to indicate relative negativity of the cooled distal electrode. The explanation offered by Garten is that the action current at the distal electrode, although probably developed with less electromotive force than at the proximal electrode, yet persists considerably longer, and therefore exercises a predominant influence upon the galvanometer.

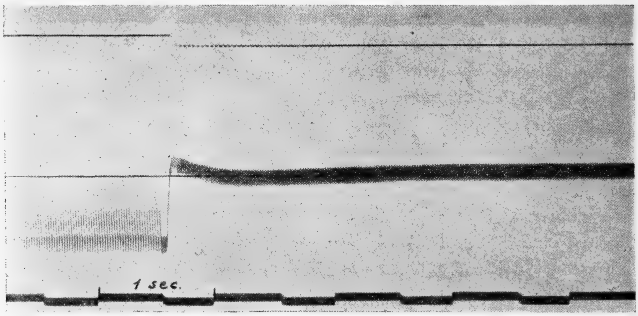


Fig. 2.

Response from nerves after preservation for 16 hours in Ringer's fluid, without fresh section. The curve shows action current as downward or positive variation.

Garten used the string galvanometer in his investigation, and the curve recorded under the conditions above-mentioned shows a deflection below the zero line during stimulation, caused by the predominant influence of the second phase of the action current, upon which the separate responses to the tetanising shocks are superposed. Garten assumes that if the two electrodes are at the same temperature the record will show merely rapid oscillations about the zero line corresponding to the diphasic action currents.

I would put forward a similar explanation for the reversal of the variation accompanying activity obtained in my experiments.

When the nerve is used immediately after removal from the body, the process of excitation is confined entirely, or almost entirely, to the uninjured

* Pflüger's Archiv. Bd. 136 S. 545, 1910.

portion of the nerve. The tissue at the cross-section is not able, owing to the injury, to develop perceptibly the condition of excitation. The result is that the action current appears as a large upward deflection—the negative variation—with the separate deflections superposed.

After preservation for some hours in Ringer's fluid, the effects of the injury diminish, as evidenced by the decreased demarcation current, and the region at the cross-section develops excitation to some extent. The negative deflection is now less, as the influence of the second phase of the action current becomes evident.

When the interval between preparation and experiment is lengthened, the action current frequently shows itself as a positive variation. In cases where this occurs the demarcation current has subsided to a large extent. The nerve, however, in the neighbourhood of the cross-section is still in an altered condition, and I think we may look upon the positive variation as evidence that the response to the induction shocks is here slower than in the remainder of the nerve, and therefore exercises a greater influence upon the galvanometer.

This is in agreement with the explanation put forward by Waller in so far as that observer distinguished by experiment between this positive variation and fixed anelectrotonus. Waller points out that the variation is particularly sensitive to the action of drugs, differing in that respect from exclusively physical electrotonus.

He contrasts the positive deflection with the usual negative deflection as regards its increase with increasing strength of stimulation. The negative deflection exhibits staircase ascent with a stimulus that is increasing step by step, while the reverse is true of the positive variation, which diminishes as the stimulus is increased, and may ultimately give place to a positive variation.

Waller does not commit himself on the question as to whether or not the appearance of positive or negative action current may depend upon different rates of development of the two states, and considers that the positive variation must be admitted to rank as a true action current, but on the whole he inclines to the view that positive deflection and positive after-deflection are of the same genus and to be interpreted as the sign of a physiologico-chemical assimilation consequent upon previous dissimilation,

This is not in accordance with the view put forward in this paper.

Waller's results have been submitted to criticism by Gotch.* This observer, who used the capillary electrometer, did not find positive change as the initial effect of stimulation in any of his experiments, and is of opinion that Waller's results are all effects due to the development of relative negativity of the tissue under the distal contact. Gotch points out that the method used by Waller, unless extended to comprise rheotome

* Schäfer's Text-book of Physiology, vol. ii., p. 540.

observations, is incapable of giving precise information as to the seat of the changes producing the positive effects.

As mentioned above my experiments with the string galvanometer support Waller's findings. The initial change may appear as a positive deflection, but I agree with Gotch in so far as the initial deflection is concerned, that its cause is relative predominance of occurrences at the distal contact, not indeed because of greater activity here but on account of the slower development of the changes.

If it is true that the positive variation depends for its appearance on difference in time relations between the changes under the two electrodes, we would expect that conditions which slow the processes would suffice to convert a negative into a positive deflection, and this is, as a matter of fact, the case.

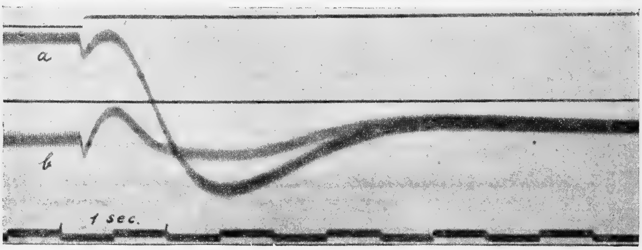


Fig. 3.

Superposed curves obtained from nerves shortly after preparation. Curve *a* at room temperature, Curve *b* after the cross-section has been cooled with cold Ringer's solution. The action current has been changed by cooling from a negative to a positive deflection. The curves show both phases of the positive after-variation and the persisting positive change.

Fig. 3 represents two records obtained from nerves which had been kept in Ringer's solution for two hours after preparation.

The curves are superposed with the zero lines coincident. Curve *a* shows the usual negative deflection during stimulation followed by the after-variation. Curve *b* gives the response obtained after the cross-section had been cooled by cold Ringer's solution. The deflection during stimulation is now positive.

This result justifies us in applying the method of explanation put forward for uninjured nerve, also to the case where the current is led off from longitudinal surface and cross-section, and where the demarcation current has diminished in amount through lapse of time.

So far we have been chiefly considering the initial variation. With regard to the after-variation most observers have followed Hering in attributing it to a process occurring in the uninjured portion of the nerve and affecting the electrode in contact with the longitudinal surface. Strong support has been afforded to that view by Garten's * work.

Gotch takes the view that positive after-variation, when it occurs, is usually due to the presence of a tail or wake of the change under the distal electrode, which is permitted to affect the instrument by some circumstance which diminishes the capacity of the tissue under the proximal contact. He mentions, however, that under other conditions positive after-effects may be developed as appears from the experiments of Hering and Head. As regards the cause and seat of such after-effects Gotch offers no opinion, and his criticism of Waller's conclusions refers only to the initial change.

Cremer, † writing before the publication of Garten's observations, declared that it was not possible upon the evidence so far adduced to decide whether the positive after-effect is due to the proximal electrode becoming more positive or to the distal electrode becoming more negative. He was of opinion that the positive effect only appears when the demarcation current is no longer of its full normal value and waves of negativity can force their way to the second electrode. Further, even conceding that the positive after-effects are conditioned solely by changes at the proximal electrode, it does not follow that the process is opposed to that which gives rise to negative change. There is the possibility that a negative change may persist corresponding to the tonic contraction of muscles, and that a temporary interruption of this may produce the positive after-effect.

With regard to this view of Cremer's, I would point out that I have obtained large positive after-effects from nerves immediately after removal from the body, when the demarcation current produced by the cross-section must be at its height.

The typical persisting effect which I have obtained after tetanisation is positive, while we would expect on Cremer's theory that it should, after a short positive deflection, be negative.

If fig. 1 is referred to it will be observed that the after-effect consists of a fall and rise of the curve, that is to say a positive variation, lasting for 4 to 5 sec., and after this the curve runs parallel to and below the zero line. The interruption of the curve is due to the introduction of a control deflection. It may be many minutes before the zero is regained.

In curve *a* of fig. 3 the after-effect is diphasic, a positive variation being followed by a negative, and the diphasic variation lasts for about 5 sec.

* *Loc. cit.*

† Nagel's Handbuch, Bd. 4, H. 2, s. 903.

There seems little doubt that these after-effects are due to a process occurring in the nerve subsequent to the process which gives rise to the action current. The positive deflection is the first phase, which affects the proximal electrode, and is alone apparent on the curve from nerves where the demarcation current is of its full value. The negative deflection constitutes the second phase and is to be attributed to the distal electrode. The whole deflection is brief, and has run its course in about 5 sec.

Although in the fresh nerve a positive after-effect only is apparent, we cannot exclude the possibility that the process underlying the after-effect

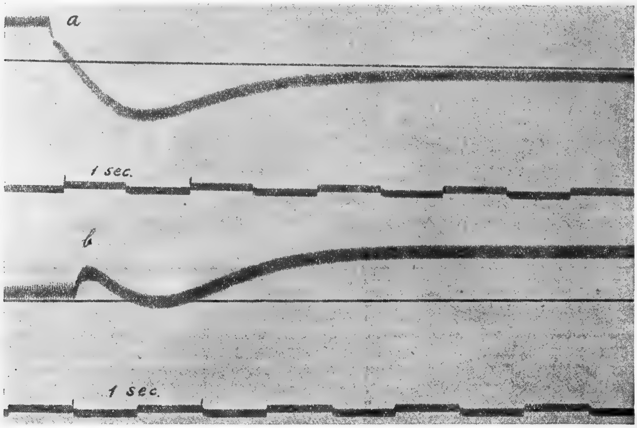


Fig. 4.

Responses from nerves 20 hours after preparation, without fresh section, 2 cm. between leading off electrodes. Curve *a* before cooling, Curve *b* after distal electrode has been cooled.

occurs to some if only a small extent in the neighbourhood of the cross section, and that in such a record as that represented by fig. 1 the curve gives the algebraic sum of the two phases.

In Garten's paper * curves are published (Plate XIX., figs. 2 and 4) from nerves which, at room temperature, showed well-developed positive after-effect, and which after cooling yielded records where this has disappeared, and, as Garten states, the curve returns to its zero position. As a matter of fact, however, careful examination of these curves demonstrates that a small negative after-effect of short duration is present. This may be the

* *Loc. cit.*

sign of a wake of the change under the distal electrode in Gotch's sense, coming to light when the process giving the after-effect is suppressed by cold, or it may be due to after-effect at the distal electrode. Some results that I have obtained seem to indicate that cooling the distal electrode favours negative after-effect. Fig. 4 is an example of this. Curve *a* is taken from a preparation which had been preserved for some hours in Ringer's solution and no fresh section made. Curve *b* was recorded after cooling the tissue under the distal electrode.

In some records taken from nerves at a considerable interval after preparation the negative phase of the after-effect is predominant, so that the curve shows practically only upward deflection at the close of stimulation and the zero line is regained in about 4 sec. This is so in fig. 5, recorded after 20 hours' preservation in Ringer's solution. Here both phases are

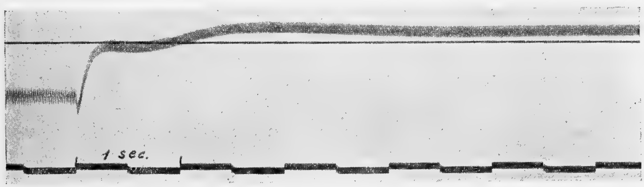


Fig. 5.

Response from nerves 20 hours after preparation, without fresh section. The action current is positive, and the second phase of the after-variation is predominant.

doubtless present, but for some reason the second predominates, and it is of importance to observe that its duration is similar to that of the first phase when alone evident, and of the whole after-variation when both phases are apparent on the curve. This figure gives a response of the type described by Waller as the fifth member of his series, and with regard to which he states that "it was far less frequently and assuredly observed, and I do not know whether in order of development it should be placed before or after the response positive followed by positive."

It appears to me that we are able to distinguish two elements in the electrical changes which follow excitation, one of which is associated with the brief process which occurs in the part or parts of the nerve that have previously been in the condition of excitation, and is evidenced by one or both phases of the positive after variation, and another which shows itself as a persisting positive change, lasting for several minutes after the first short-lived process has terminated. This second intimately depends on the presence and amount of the demarcation current. In the case of fresh nerves, where the demarcation current is large as in fig. 1, the persisting change has a value of about 5×10^{-5} volt, while the first element gives a change of about 8×10^{-5} volt. When the demarcation current has disappeared the second element is no longer perceptible. It would appear that tetanisation increases the demarcation current when the latter is present.

It is evident that another view of this persisting change might be adopted, and the positive after-variation described as large at first and leaving behind it a wake of less amount and longer duration. The disappearance of the persisting change would then be correlated less with diminution of the demarcation current than with the accompanying development of the second phase and its wake.

We may exclude the possibility that the persisting positive change is caused by Anelectrotonus, which depends on the electrolytic polarisability of nerve. The tetanising current used is a weak one, being of minimal or slightly above the minimal strength required to stimulate the nerve.

Conclusions.

The action current recorded from fresh isolated nerve on tetanisation when the leading off electrodes are placed on longitudinal surface and cross-section is monophasic, or if diphasic, the second phase is very slightly developed. The individual responses to the tetanic shocks are superposed on the deflection.

When the demarcation current has diminished in value the action current is diphasic. Either phase may predominate in the record, depending on two factors—electromotive force and rate of change at the two electrodes.

The after-effect is compounded of two parts: (1) a variation opposite in direction to the action current and monophasic or diphasic according to the condition of the tissue under the distal electrode, and (2) a persisting positive variation, probably to be ascribed to increase in the demarcation current caused by tetanisation.

DESCRIPTION OF A NEW SPECIES OF STING-RAY (TRYGON) FROM SOUTH AFRICA.

By J. D. F. Gilchrist, D.Sc., F.R.S.S.Af.

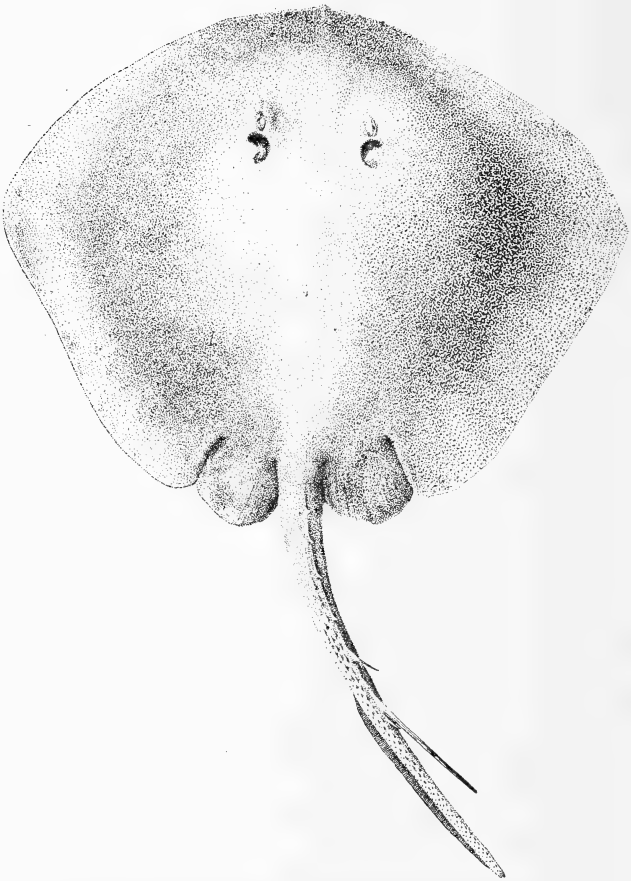
(Read May 15, 1912.)

Three species of the "Pijl-staart or "Sting-ray" (Trygon) have been recorded from South African waters. The following is a description of a fourth, which seems to be a new species. It is a large fish about 6 feet in total length and 4 feet in breadth, and does not seem to be very abundant. It was caught by Mr. W. F. R. Schreiner by rod and line off the rocks at St. James in False Bay.

The disc is broader than long, the anterior border is rounded with no projection of the snout. The tail is slightly shorter than the body. Teeth with transverse lamellæ. There are no tubercles on the back of the body nor on the fins, but a number occur on the tail, where they are small and numerous; they are found on the dorsal surface of the tail from about its middle backwards, and on its ventral surface they begin slightly further back. Towards the extremity they occur not only on the dorsal and ventral aspect, but completely round this region. There are seven large spines in a row in the dorsal surface of the tail; the first five gradually increase in size from half an inch in the case of the first to 3 inches in the fifth; the sixth is much larger, being 11 inches in length; behind the sixth and partly concealed by it is the seventh, which is again small, being 1 inch in length. A low cutaneous flap, 12½ inches long, occurs on the under surface of the tail, beginning below the root of the largest spine and ending near its free extremity; it is not continued to the end of the tail, falling short of it by about 3 inches; the greatest depth of this flap occurs in its anterior portion, where it is three-fourths of the diameter of the tail above it.

The colour of the fish is uniform dark slate above and white below, except at the margin and under surface of the fins where it is grey.

The length from snout to end of tail is 6 feet, the greatest length of the body 3 feet 2 inches, the greatest breadth 4 feet.



Trigon Schreineri, n. sp.

A SHORT NOTE ON THE OCCURRENCE OF A LEUCOCYTOZOON INFECTION. HOST: THE OSTRICH.

By J. Walker, M.R.C.V.S.

(Read May 15, 1912.)

(Plate II.)

In November, 1911, the writer was requested to investigate the cause of the mortality occurring amongst ostrich chicks on a farm in the Middelburg District, Cape Province. The percentage of deaths on a number of farms, of ostrich chicks of about 6–8 weeks, is large, and from the following particulars furnished by the owner the losses have also been considerable on this farm.

In 1910 out of a total of 745 hatched 351 were reared.

In 1911 out of a total of 784 hatched 295 were reared.

In 1909 the losses *were small*, 360 were reared of a total of 365 hatched.

The cause of death was attributed by the owner to, in some instances, parasitic infection (intestinal) and liver disease, and in many cases it was unknown.

A number of sick chicks of about 6–8 weeks old were examined; the *symptoms* noted were disinclination to feed, loss of condition, stunted growth, paleness of the buccal mucous membrane, skin of body and around eyes bluish, inability to keep up with the rest of the brood when driven; chicks were noticed sick some days before death.

A number of post-mortems were held, with the result that death, in some instances, was found to be due to parasitic infection (Strongylus Douglasi, and Tænia). The absence of intestinal parasites was, however, noted in some cases, and the cause of death had thus to be disassociated with wire-worm and tape-worm infection. It was found that the usual method of rearing and feeding chicks had not been departed from, and the particulars furnished and observations made pointed to the existence of a disease of a specific nature.

A microscopical examination of the organs showed no constant changes, but on examination of the blood the presence of a Leucocytozoon was frequently noted.

So far in South Africa a similar parasite had only been observed in some species of wild birds, *e.g.*, a hawk, and consequently from an economic point of view its presence was not considered of much importance. It will now, however, be necessary to ascertain whether it enters into the etiology of some of the at present unknown diseases of ostrich chicks.

Microscopical appearance of the Parasite in Stained Blood-smears.

In dried blood-smears fixed with methyl alcohol and stained with Giemsa, two main types of parasites, which apparently correspond with male and female Gametocytes, have been noted.

The Female Gametocyte occurs most frequently.

The shape varies. Sometimes it is more or less rounded, but it may be irregular, probably due to distortion caused in making the smears.

The size varies from 11–15 microns in length and 9–13 microns in width, the rounded form being generally from 14 to 15 μ in diameter.

The protoplasm of the parasite stains deeper than in the case of the male gametocyte, and scattered throughout it are a number of metachromatic granules, which appear more distinctly in some of the parasites than in others. A number of small clear spaces occur throughout the protoplasm. Situated in various positions, generally at the centre or near the edge, is an aggregation of small chromatin granules which represents the *nucleus.*

In most instances a large chromatin granule, situated in the mass of the chromatin granules or at the side of or some distance from these, stands out distinctly.

The nucleus of the host cell is always altered in shape. In most cases it is elongated and enlarged and situated at the margin of the parasite.

The Male Gametocyte, as stated above, occurs less frequently than the female.

The shape varies. It is usually more or less rounded.

Size. The rounded forms average 9 to 10 μ in diameter.

The protoplasm stains less densely than in the case of the female.

The chromatin granules of the *nucleus* are generally scattered throughout the cell, and sometimes they are large and widely separated, in which case they are very distinctly seen.

The nucleus of the host cell is irregular in shape but less elongated and smaller than in the case of the cell invaded by the female. It is found at the edge of the parasite.

Contrary to what has been observed in Leucocytozoon infection of other birds, in some species no *spindle-shaped formation* of the host-cell has so far been observed in stained blood-smears of infected ostriches.

Occurrence amongst Ostriches and Age of Birds Affected.

For the purpose of ascertaining to what extent the infection occurs amongst ostriches, a number of blood-smears from chicks and adult birds were collected from various farms, with the result as shown in the following table :—

No.	Farm.	Date.	Number of Smears Examined and Ages of Birds.	Result.	Remarks.
1	B.H.	31/1/12	12 × 7 year old ostriches 6 × 3 ,, ,, 12 × 18 months old ostriches 12 × 2½ ,, ,, 12 × 6 weeks ,,	Negative ,, ,, 9 leucocytozoon infection 11 ,, ,,	Mortality amongst chicks on this farm heavy this year and previous years.
2	P.	12/2/12	11 × 7 year old ostriches 17 × 2 ,, ,, 7 × 2 months old ostriches	Negative ,, ,,	Little or no mortality this year amongst chicks on this farm.
3	C.	31/1/12	4 × 6 year old ostriches 6 × 15 months old ostriches 6 × 7 ,, ,, 15 × 2 ,, ,, 2 × 6 weeks ,, 4 × 2 ,, ,,	Negative ,, 1 leucocytozoon infection 4 ,, ,, 2 ,, ,, Negative	Losses have occurred this year and also in previous years.
4	G.	21/1/12	8 × 1 month old chicks 1 × 5 ,, ,, 4 aged ostriches	Negative ,, ,,	Mortality heavy on this farm this year.
5	T.	18/1/12	4 × 18 months old ostriches 1 × 5 ,, ,, 5 × 4 ,, ,, 1 × 2½ ,, ,, 2 × 3 ,, ,, 6 × 2 ,, ,, 7 × 2 days old ostriches	Negative ,, 4 leucocytozoon Negative ,, 3 leucocytozoon infection Negative	Mortality heavy on this farm during this year and previous years.
6	B.H.	17/11/11	1 × 3 months old ostriches 2 × 7 weeks old chicks 4 × 6 ,, ,, 1 × 5 ,, ,, 1 × 4 ,, ,,	Negative Leucocytozoon infection ,, ,, ,, ,, ,, ,,	Mortality heavy on this farm during the year and some previous years.

Conclusion.

A leucocytozoon infection has so far been observed in ostrich chicks aged from 4 to 7 months. The examination of a number of smears collected from adult ostriches on farms on which the infection is common amongst chicks, gave negative results.

Since this parasite has so far not been recorded, I propose that it be named *Leucocytozoon struthionis*.

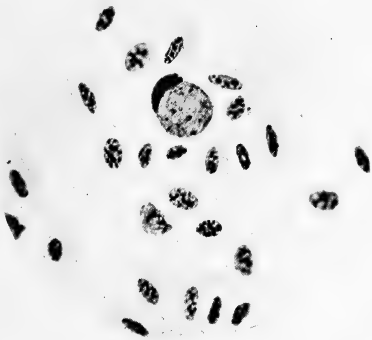


Plate 1.
Female Gametocyte.
(Magnified × 900 approx.)

Plate 2.
Male Gametocyte.
(Magnified × 900 approx.)

Plate 3.
Field showing Male and Female Gametocyte.
(Magnified × 500 approx.)

West, Newman proc.

VALENCY AND CHEMICAL AFFINITY.

By James Moir, M.A., D.Sc., F.R.S.S.Af.

(Read June 19, 1912.)

Two and a half years ago (Trans. R.S.S.A., vol. i., part 2, p. 413; also J.C.S., November, 1909) the author showed that the atomic weights could be fairly exactly calculated by making use of a *proton*, μ, of atomic weight about 0·009.

The author has now discovered evidence that this proton may really be, as was suspected in 1909, the true cause of valency and of chemical combination. This evidence consists in the fact that practically the same value of μ is given by the three most exact determinations of molecular ratios that he is acquainted with.

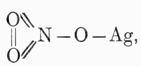
(i.) *Synthesis of Water.*—This gives $H = 1{\cdot}0077$ when oxygen $= 16$. Assume as before that hydrogen consists of $\overline{H}$ (non-valent, of atomic weight 1 exactly) plus μ, and that oxygen $= 16\,\overline{H} + 2\,\mu$.

Then we have—

$$\frac{16(1+\mu)}{16+2\,\mu} = 1{\cdot}0077\,;$$

or by the binomial theorem, $1{\cdot}0077 = 1 + \frac{7}{8}\mu$; whence $\mu = 0{\cdot}0088$.

(ii.) *Stas's Corrected Ratio of Silver Nitrate to Silver.*—This was found to be 1·57473. Assume silver nitrate to be—



i.e., with oxygen tetravalent and eight bonds. Its molecular weight is then—

$$108 + 14 + 48 + 8\,\mu = 170 + 8\,\mu\ (\overline{H} = 1),$$

when metallic silver is 108 $\overline{H}$.

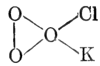
Hence—

$$170 + 8\,\mu = 108 \times 1{\cdot}57473.$$

This gives—

$$\mu = 0{\cdot}00885.$$

(iii.) *Conversion of Chlorate to Chloride.*—The latest experimental ratio of $KClO_3/KCl$ is 1·643819. Assume that $KClO_3$ is—



(*i.e.*, that chlorine is always monovalent), and that—

$$K = 39{\cdot}100\,\overline{\overline{H}},$$

and—

$$Cl = 35{\cdot}500\,\overline{\overline{H}}.$$

Then—

$$\frac{KClO_3 + 5\mu}{KCl + \mu} = 1{\cdot}643819.$$

This gives—

$$\mu = 0{\cdot}0086.$$

Generally speaking, the author is inclined to think that the tetravalency of oxygen should play a large part in chemical theory, and should be used to explain the so-called "higher valencies" of most of the elements.

THE RAINFALL ON TABLE MOUNTAIN.

By Thomas Stewart, M.Inst.C.E.

(Read June 19, 1912.)

Observations of the rainfall on Table Mountain were first taken in January, 1881, when the late Mr. John G. Gamble, Hydraulic Engineer for the Cape Colony, placed a rain-gauge at a point known as Disa Head, which is about 2,500 feet above sea-level. During the month of May of the same year another gauge was erected at a station called Waai Kopje, which is about 3,100 feet above sea-level and about half-way between Disa Head and the top of the mountain. In September and October of 1884 two additional gauges were erected—one near Kasteel Poort, 2,483 feet above sea-level, and the other at a station called St. Michael's, 3,050 feet above sea-level. These four gauges were the only ones in existence until 1888, when I placed another gauge in the Disa Valley near where the middle Wynberg storage reservoir has since been built, and about 1,500 yards from the Disa Head gauge. My reason for placing this gauge so near to the Disa Head station was that the amount of rainfall registered at the Disa Head gauge appeared to be considerably below that which fell at a short distance from it. The readings obtained at the new gauge proved that the surmise was correct, and the information was utilised by me when selecting a site for the first storage reservoir built on Table Mountain, viz., that known as the Wynberg Middle Reservoir. The taking of readings of this gauge was not carried on regularly, and was discontinued altogether for a few months, but in May, 1892, two gauges were erected at other stations in the vicinity. Both of these places were nearer to the Disa Head gauge than the one originally adopted, the nearer station being only 500 yards and the further one 1,300 yards away.

Observations were taken of these gauges continuously from May, 1892, to June, 1904. They showed that that neighbourhood received a larger rainfall than was indicated by the Disa Head gauge. Comparing the averages for the eleven years, 1893 to 1903 inclusive, it will be seen that the relation is as follows:—

Disa Head	37·53 inches.
Wynberg Watershed...........................	58·18 ,,
Wynberg Reservoir (Middle)	55·60 ,,

As the results obtained from the rain-gauge which had been fixed temporarily near the middle Wynberg reservoir showed that great differences in the rainfall might be expected to exist elsewhere on the mountain, I decided in 1892, when I was investigating the question of the water-supply to Cape Town, to recommend the Town Council to provide additional gauges. On these being supplied, they were placed at various points within what has now become known as the catchment area to the Cape Town reservoirs, which extends to about 667 acres. The results obtained are, of course, applicable to a much larger portion of the mountain than that utilised by Cape Town. In 1900 another rain-gauge was erected near the existing caretaker's house.

The duty of providing for the observing of rain-gauges erected at Disa Head, Kasteel Poort, Waai Kopje, and St. Michael's was relegated to the Meteorological Commission. The actual observations were taken monthly for some years by Mr. Ellerton Fry, Secretary to the Commission, and by Mr. Gamble and myself. Afterwards other observers carried on the work. In 1896 the gauge at the Disa Head was observed daily by one of the staff employed on the reservoir works, instead of monthly as previously; but the other three gauges continued to be read by an observer appointed by the Meteorological Commission until a few years ago when the reading of these was undertaken by the Cape Town Council.

The six additional rain-gauges placed in position in 1893, together with that placed at the caretaker's house in 1900, were observed, under my direction, by one of the staff employed on the reservoir works until their completion in 1904. Since then the observing of these gauges has been done for the Cape Town Council chiefly by the caretaker, Mr. H. Thorsen, who had made many of the observations previous to 1904 and had proved himself to be a careful and painstaking observer.

Since 1904 additional rain-gauges have been placed at various points on the mountain and valuable information regarding the distribution of the rainfall has been obtained from them, but as the gauges have not been observed for 10 consecutive years I do not propose to refer to them further in this paper.

Table "A" shows the stations above the 2,400-foot level at which observations of rainfall have been taken for periods extending from 10 to 30 years. The heights above sea-level have been taken by spirit-levelling, and are, with certain exceptions, given to the nearest foot.

Of the whole of the stations from which records have been received for 10 years or more, at the end of 1911 only two had been in existence for 30 consecutive years, namely, Disa Head and Waai Kopje; but another two had been in existence for 27 years, namely, Kasteel Poort and St. Michael's. Comparing the averages for Disa Head and Waai Kopje for the 30 years with those of the same stations for the 27 years it will be seen that the differences are inconsiderable, thus :—

No. of Years.	Period.	Average Yearly Rainfall in Inches.			
		Disa Head.	Waai Kopje.	St. Michael's.	Kasteel Poort.
30	1882–1911	39·24	66·83	—	—
27	1885–1911	39·44	67·63	61·64	75·24

It may therefore be assumed for all practicable purposes that the averages at Kasteel Poort and St. Michael's would have been approximately the same for 30 years as for 27 years.

Continuing the comparison of the records for shorter periods, I would direct attention to Table "B," where the averages for all the stations in existence for periods of 30, 27, 19, 18, and 12 years previous to 1912 are tabulated, as well as the averages for the 11 years 1893 to 1903 inclusive and the 10 years 1894 to 1904 inclusive. Taking the averages for the 11 years for the three stations, Waai Kopje, St. Michael's, and Kasteel Poort, and comparing them with the averages for the same stations for 27 years :—

No. of Years.	Period.	Average Yearly Rainfall in Inches.		
		Waai Kopje.	St. Michael's.	Kasteel Poort.
27	1885–1911	67·63	75·24	61·64
11	1893–1903	68·03	75·54	61·09

It will be seen that the maximum difference between the averages for the two periods is only 0·55 inch, which is scarcely appreciable. The difference between the averages of the Waai Kopje gauge for 11 and

30 years is only 1·20 inch, which may also be considered as of no importance for practical purposes. The records for Disa Head do not show a similar state of affairs; but, as already pointed out, the rainfall recorded at this station does not afford a safe indication of what takes place on other parts of the mountain.

It may therefore be said that in so far as the determining of the average annual rainfall is concerned the statistics for the 11 years 1893 to 1903 inclusive are as suitable as the data obtained over the period of 30 years.

The agreement of the averages for the 11 years 1893 to 1903 inclusive with the averages for the same rain-gauges for the 30 years 1882 to 1911 inclusive is more than usually interesting, because the first year of the 11-year period was, with one exception (1896), the driest which has been recorded on Table Mountain since the taking of observations began, and the three following years, 1894, 1895, and 1896, were the three consecutive driest years. In striking contrast to the state of affairs which ruled during the first few years of the period is the fact that the last year but one of the period (1902) was the wettest year which has been recorded since the taking of observations on the mountain began.

So far I have dealt chiefly with the average rainfall as observed at the various stations, but this paper would be incomplete without some reference being made to the wettest station. As will be seen by Table "A," the heaviest rainfall is recorded at McLear's Beacon gauge, which is on the summit of the mountain. Regular records were obtained from this station for the first time in 1893. For 1896, which was the driest year, the total rainfall was 73·34 inches as compared with 59·58 inches at St. Michael's, which up to 1893 was the station returning the heaviest rainfall. The heaviest rainfall for any one month was recorded in August, 1899, when 36·58 inches fell, and for one year—in 1902—when the total fall was 126·18 inches.

TABLE "A."

Table Mountain Rainfall.

	Station	Disa Head.	Waai Kopje.	Kasteel Poort.	St. Michael's.	McLear's Beacon.	Waai Vlei.	Dam.	House.	Planta-tion.	Wynberg Reservoir.	Wynberg Watershed.
	Height above sea	2,500 ft.	3,100 ft.	2,483 ft.	3,050 ft.	3,586 ft.	2,900 ft.	2,413 ft.	2,496 ft.	2,426 ft.	2,388 ft.	2,376 ft.
	Year.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
	1882	49·23	60·24	—	—	—	—	—	—	—	—	—
	1883	32·68	62·96	—	—	—	—	—	—	—	—	—
	1884	30·29	55·66	—	—	—	—	—	—	—	—	—
	1885	35·18	62·49	63·71	77·86	—	—	—	—	—	—	—
	1886	40·69	54·67	53·87	67·46	—	—	—	—	—	—	—
	1887	41·53	54·09	53·61	61·29	—	—	—	—	—	—	—
	1888	57·92	78·35	76·21	99·08	—	—	—	—	—	—	—
	1889	43·30	60·61	60·06	67·09	—	—	—	—	—	—	—
	1890	45·68	55·08	57·37	66·00	—	—	—	—	—	—	—
	1891	46·48	65·75	55·66	71·67	—	—	—	—	—	—	—
	1892	59·85	80·36	80·69	97·89	—	—	—	—	—	—	—
	1893	36·21	53·85	51·30	64·74	79·65	60·21	—	—	—	51·82	50·57
	1894	36·36	54·35	48·11	63·15	74·08	56·77	46·98	—	62·37	47·30	50·41
	1895	38·06	58·77	53·66	69·90	94·37	63·72	50·05	—	69·84	49·59	57·14
	1896	38·68	52·76	52·16	59·58	73·34	55·18	49·30	—	60·69	40·83	47·28
	1897	38·82	70·27	58·85	75·78	98·24	77·32	62·65	—	76·75	54·33	58·53
	1898	43·08	69·51	66·63	75·81	92·67	71·72	65·33	—	79·77	60·55	57·29
	1899	34·95	76·64	64·95	84·02	105·86	82·18	63·16	—	83·22	59·99	60·53
	1900	30·12	62·54	57·00	65·78	76·17	62·91	55·06	56·62	64·72	47·38	51·89
	1901	35·72	64·62	61·34	72·67	83·70	72·47	63·96	64·74	72·19	57·05	61·55
	1902	43·95	96·12	83·96	105·22	126·18	107·15	87·53	88·19	99·47	80·59	81·60
	1903	36·95	88·89	74·07	94·26	113·04	90·35	78·08	83·27	90·24	62·22	63·15
	1904	46·12	92·00	79·94	95·57	118·69	93·62	86·25	88·32	—	—	—
	1905	41·15	82·78	64·98	80·64	101·64	83·48	73·43	75·07	—	—	—
	1906	35·92	60·30	55·21	64·13	67·05	60·39	59·66	58·19	—	—	—
	1907	30·81	67·60	55·21	64·76	78·76	63·54	58·44	57·23	—	—	—
	1908	38·58	71·09	62·68	75·52	77·38	70·54	67·91	65·49	—	—	—
	1909	26·39	67·65	55·12	68·36	80·13	67·35	56·53	59·27	—	—	—
	1910	28·10	60·07	54·38	66·06	72·19	63·65	55·43	51·65	—	—	—
	1911	34·45	64·96	63·60	77·23	83·53	80·05	66·46	63·45	—	—	—
Averages for—	Periods—											
30 years	1882–1911	39·24	66·83	—	—	—	—	—	—	—	—	—
27 ,,	1885–1911	39·44	67·63	61·64	75·24	—	—	—	—	—	—	—
19 ,,	1893–1911	36·55	69·19	61·21	74·90	89·30	72·77	—	—	—	—	—
18 ,,	1894–1911	36·56	70·89	61·77	75·48	89·83	73·46	64·37	—	—	—	—
12 ,,	1900–1911	35·69	73·22	63·95	77·51	89·87	76·29	67·39	67·62	—	—	—
11 ,,	1893–1903	37·53	68·03	61·09	75·54	92·48	72·72	—	—	—	55·60	58·18
10 ,,	1894–1903	37·67	69·45	62·07	76·61	93·76	73·97	62·21	—	75·92	55·98	58·94

TABLE "B."

Average Rainfalls on Table Mountain.

Month.	30 Years, 1882–1911.		27 Years, 1885–1911.				19 Years, 1893–1911.						18 Years, 1894–1911.						
	Disa.	Waai Kopje.	Disa.	Waai Kopje.	Kasteel Poort.	St. Michael's.	Disa.	Waai Kopje.	Kasteel Poort.	St. Michael's.	Mac-Lear's.	Waai Vlei.	Disa.	Waai Kopje.	Kasteel Poort.	St. Michael's.	Mac-Lear's.	Waai Vlei.	Dam.
January ...	1·20	2·26	1·26	2·42	2·02	2·54	1·40	2·87	2·39	3·01	3·16	2·63	1·46	2·93	2·47	3·08	3·21	2·71	2·49
February ...	1·14	1·83	1·21	1·88	1·59	2·16	0·96	1·64	1·32	1·88	1·85	1·62	0·96	1·65	1·33	1·89	1·81	1·65	1·48
March	2·00	3·06	2·05	3·15	2·83	3·45	2·04	3·42	2·92	3·60	3·73	3·40	2·14	3·61	3·08	3·79	3·92	3·56	3·24
April	3·56	5·23	3·47	5·14	4·81	5·73	3·16	4·99	4·55	5·52	6·67	5·88	3·10	4·99	4·48	5·43	6·48	5·66	4·87
May............	5·25	9·06	5·34	9·21	8·26	10·00	4·26	8·54	7·41	8·88	10·17	8·26	4·32	9·01	7·57	9·09	10·51	8·50	7·50
June	5·84	10·40	5·86	10·60	10·12	12·23	5·46	10·85	10·22	12·20	14·60	11·68	5·42	10·99	10·25	12·22	14·01	11·75	10·09
July	5·25	8·90	5·08	8·81	8·53	10·37	4·55	8·98	8·22	10·05	12·77	9·74	4·58	9·18	8·42	10·26	13·48	9·97	8·39
August	4·59	8·39	4·71	8·75	7·79	9·51	4·42	9·10	7·86	9·60	12·72	10·01	4·38	9·24	7·85	9·53	12·77	9·97	8·07
September	3·50	5·82	3·46	5·69	5·12	6·20	3·47	6·08	5·29	6·51	8·57	6·99	3·38	6·15	5·13	6·36	8·33	6·91	5·88
October......	3·17	5·31	3·18	5·23	4·95	5·93	3·28	5·88	5·42	6·50	7·34	6·07	3·16	5·94	5·34	6·42	7·32	6·02	5·36
November..	1·92	3·29	1·99	3·37	2·84	3·49	1·92	3·58	2·99	3·70	4·06	3·27	1·97	3·76	3·10	3·79	4·16	3·38	3·22
December..	1·82	3·28	1·83	3·38	2·78	3·63	1·63	3·26	2·62	3·45	3·66	3·22	1·69	3·44	2·75	3·62	3·83	3·38	3·78
Totals ...	39·24	66·83	39·44	67·63	61·64	75·24	36·55	69·19	61·21	74·90	89·30	72·77	36·56	70·89	61·77	75·48	89·83	73·46	64·37

Month.	12 Years, 1900–1911.							
	Disa.	Waai Kopje.	Kasteel Poort.	St. Michael's.	MacLear's.	Waai Vlei.	Dam.	House.
January ...	1·61	3·39	2·90	3·45	3·50	3·07	2·92	2·98
February ..	1·01	1·81	1·47	2·17	1·97	1·88	1·69	1·68
March	1·92	3·68	3·00	3·95	3·84	3·48	3·19	3·17
April.........	3·04	4·94	4·41	5·40	6·39	5·71	5·09	5·15
May	4·33	9·71	8·27	9·87	11·19	9·31	8·18	8·36
June	5·34	12·09	10·72	12·80	15·03	12·46	10·88	11·01
July	3·98	8·60	8·34	9·57	12·06	9·64	8·20	8·32
August......	4·09	9·15	7·67	9·26	11·50	9·43	8·07	7·99
September	3·35	6·29	5·38	6·65	8·90	7·66	6·33	6·32
October ...	3·15	6·11	5·54	6·62	7·19	6·12	5·72	5·42
November	1·83	3·55	2·87	3·47	3·76	3·22	3·22	3·14
December	2·04	3·90	3·38	4·30	4·54	4·31	3·90	4·08
Totals ...	35·69	73·22	63·95	77·51	89·87	76·29	67·39	67·62

Month.	11 Years, 1893–1903.							
							Wynberg.	
	Disa.	Waai Kopje.	Kasteel Poort.	St. Michael's.	MacLear's.	Waai Vlei.	Reser-voir.	Water-shed.
January ...	1·53	3·19	2·64	3·37	3·90	3·05	2·56	2·63
February ..	1·01	1·73	1·50	2·00	2·02	1·63	1·38	1·42
March	2·16	3·10	2·77	3·11	3·65	3·27	2·87	2·98
April.........	3·19	5·15	4·55	5·62	6·87	5·96	4·23	4·58
May	4·38	8·39	7·31	8·86	10·44	8·13	6·61	6·92
June	5·27	9·76	10·10	12·08	14·04	11·58	8·45	8·45
July	5·17	9·93	8·77	11·08	14·94	10·57	7·73	8·24
August......	4·51	8·64	7·67	9·57	13·20	10·07	7·51	7·80
September	3·81	6·33	5·59	6·84	9·24	7·18	5·46	5·71
October ...	3·42	6·04	5·64	6·90	7·38	6·04	4·88	5·25
November	2·07	3·51	2·93	3·78	4·29	3·33	2·54	2·80
December	1·01	2·26	1·62	2·33	2·51	1·91	1·38	1·40
Totals ...	37·53	68·03	61·09	75·54	92·48	72·72	55·60	58·18

Month.	10 Years, 1894–1903.									
							Wynberg.			
	Disa.	Waai Kopje.	Kasteel's Poort.	St. Michael's.	MacLear's.	Waai Vlei.	Reser-voir.	Water-shed.	Dam.	Plantation.
January ...	1·64	3·37	2·81	3·53	4·05	3·25	2·68	2·78	2·83	3·32
February ..	1·02	1·76	1·54	2·02	1·97	1·69	1·39	1·44	1·51	1·78
March	2·35	3·38	3·03	3·39	3·99	3·56	3·13	3·25	3·24	3·79
April.........	3·10	5·11	4·43	5·47	6·56	5·58	3·98	4·38	4·52	5·40
May	4·51	8·78	7·58	9·23	11·07	8·55	6·96	7·29	7·42	8·83
June	5·18	9·83	10·15	12·09	13·77	11·70	8·46	8·48	9·68	11·89
July	5·29	10·27	9·18	11·57	15·57	11·05	7·97	8·50	9·14	11·12
August......	4·44	8·63	7·63	9·43	13·33	10·00	7·38	7·77	7·65	10·27
September	3·68	6·07	5·34	6·56	8·89	7·06	5·20	5·51	6·05	7·42
October ...	3·21	6·11	5·52	6·79	7·33	5·93	4·62	5·04	5·16	6·38
November	2·18	3·68	3·11	4·01	4·51	3·54	2·71	2·98	3·20	3·66
December	1·07	2·46	1·75	2·52	2·72	2·06	1·50	1·52	1·81	2·06
Totals ...	37·67	69·45	62·07	76·61	93·76	73·97	55·98	58·94	62·21	75·92

ADDENDUM TO REVISED LIST OF THE FLORA OF NATAL.

By J. Medley Wood.

(Read June 19, 1912.)

PREFACE.

In January, 1910, a Supplement to the "Revised List of the Flora of Natal" was published by the Royal Society of South Africa, the Revised List having been published in Part 2 of Vol. XVIII., 1908, of the *Transactions of the South African Philosophical Society*. Since that time a number of names has been added to that List, chiefly by the publication of the Parts of the "Flora Capensis," a few of our more recent collections, and a larger number of the collection of Mr. H. Rudatis, who has been for some time living in a district which has evidently not been much frequented by botanists. Mr. Rudatis very kindly allowed my assistant and myself to look over his collections, and further lent to us some of the newer or more critical species. I therefore think that the time has come to compile a list in the form of an Addendum, hoping that these rather disconnected Lists may be found useful in future when a more complete List of the Natal Flora with descriptions and Keys may be published by some one who may be in a better position than myself to undertake the work.

My very hearty thanks are due to Mr. Rudatis for the specimens which he has given to the Herbarium, and which are much appreciated, and also to Miss Franks who has assisted me in preparing this List.

J. M. W.

ANONACEÆ.

Popowia Buchanani Engl. and Diels. Fairfield, Alexandra County, *Rudatis*, 807. January.

BIXACEÆ.

Aberia tristis Sond. Normandine, *T. R. Sim.*

MALVACEÆ.

Hibiscus verrucosus G. and P. Ifafa, 1,800 feet alt., *Rudatis*, 380. Probably a variety of **H. cannabinus.** Not seen by us.

STERCULIACEÆ.

Hermannia velutina DC. Malvern, 600 feet alt., *Wood*, 11846.

GERANIACEÆ.

Impatiens Flanaganæ Hemsley. Umtwalumi, 1,500 feet alt., *Rudatis*, 1277.

Pelargonium Woodii N. E. Brown. Slopes of Drakensberg, 5–6,000 feet alt., *Wood*, January, 1886; similar situations, *Wylie.* Cultivated in Botanic Gardens, Durban. Evidently closely related to **P. Bowkeri,** though the mature leaves are very different. (See "Natal Plants," vol. vi., pl. 583, 584).

MELIACEÆ.

Trichilia umbellata (C.) DC. Umtwalumi, 2,500 feet alt., October, *Rudatis*, 120.

ILICINEÆ.

Ilex mitis (L.) Rad. Alexandra County, 1,800 feet alt., November, *Rudatis*, 471.

RHAMNEÆ.

Rhamnus Zeyheri Sond. Lower Umzimkulu, 100 feet alt., *Bazley;* Camperdown, 2,000 feet alt., *Miss Franks.* This tree yields the "Red Ivory Wood" of the colonists. (See "Natal Plants," vol. vi., pl. 590).

Noltea natalensis Schltr. Umtwalumi, 3,000 feet alt., December, *Rudatis*, 584.

AMPELIDEÆ.

Cissus connivens Lam. Ellesmere, Alexandra County, December, *Rudatis*, 562. According to the Index Kewensis a native of Madagascar.

ANACARDIACEÆ.

Rhus villosissima Engl. Ellesmere, 2,000 feet alt., November, *Rudatis*, 507.

LEGUMINOSÆ.

Argyrolobium pauciflorum E. and Z. Camperdown, 2,000 feet alt., October, *Miss Franks* in Herb. *Wood*, 11758; also in Cape Colony.

Indigofera corniculata E. M. Sydenham, near Durban, 3–500 feet alt., *Wood*, 11409; also between Umtata and Umzimvubu, *Drege.*

Glycine Wilmsii Harms. Alexandra County, 1,800 feet alt., December, *Rudatis*, 520.

Acacia eriadenia Bth. Near Durban, 150 feet alt., October, *Wood*, 7188. Not uncommon in coast districts.

Dolichos nodiflora L. Alexandra County, April, *Rudatis*, 636. Not in Index Kewensis nor known to us; we have not seen the specimen.

CRASSULACEÆ.

Kalanchoe paniculata Harv. Ifafa, 150 feet alt., April, *Rudatis*, 349; also Vetriver, *Burke* and *Zeyher*.

DROSERACEÆ.

Drosera natalensis Diels. Jolivet, 3,000 feet alt., October, *Rudatis*, 138.

LYTHRARIEÆ.

Nesæa Woodii Koehne. Fort Yolland, Zululand, March, *Wood*, 8986.

ONAGRARIEÆ.

Epilobium natalense Haussk. Only known to us from a drawing, without information.

SAMYDACEÆ.

Casearia Junodii Schinz. 'Nkandhla, 4–5,000 feet alt., March, *Wood*, 8987.

FICOIDEÆ.

Mesembryanthemum cordifolium L.f. Camperdown, 2,000 feet alt., April, *Miss Franks* in Herb. *Wood*, 11811.

2. **M. Flanagani** Kensit. In Botanic Garden, Durban, the plant brought from Inchanga, 2,100 feet alt., April, *Wood*, 11805.

UMBELLIFEREÆ.

Alepidea Baurii O. Kuntze, forma pusilla. Summit of Amawaqua, 6–7,000 feet alt., March, *Wood*, 4587.

2. **A. concinna** Dummer, sp. nov. ined. Inanda, 1,800 feet alt., October, *Wood*, 251.

3. **A. Jacobzii** Dummer, sp. nov. ined. Hoffenthal, Weenen County, 4–5,000 feet alt., January, *Wood*, 3502.

4. **A. longifolia** E. M. Var. **angusta** Dummer, ined. Van Reenen, 5–6,000 feet alt., *Wood*, 5735; Noodsberg, 2–3,000 feet alt., March, *Wood*, 5315.

5. **A. Thodei** Dummer, sp. nov. ined. Mont Aux Sources, Drakensberg, February, *Thode* in Natal Herbarium, 10770; also in Cape Colony.

Peucedanum araliaceum Bth. and Hk. Ellesmere, 2,000 feet alt., January, *Rudatis*, 611; also in Tropical Africa.

2. **P. Wilmsianum** Walff. Alexandra County, 1,800 feet alt., January, *Rudatis*, 812.

4

RUBIACEÆ.

Psychotria Bachmannii Krause. Ellesmere, 2,000 feet alt., September, *Rudatis*, 418.

DIPSACEÆ.

Cephalaria Bachmannii Engl. Alexandra County, 1,800 feet alt., September, *Rudatis*, 423.

COMPOSITÆ.

Adenostemma viscosum Forst. Alexandra County, 1,800 feet alt., February, *Rudatis*, 276.

Helichrysum adenocaulon DC. Van Reenen's Pass, 5–6,000 feet alt., March, *Penther*, 1432; 1438.

2. **H. calocephalum** Schltr. Dumisa, Alexandra County, October, *Rudatis*; Liddesdale, 4,000 feet alt., *Wood*, 4251; Hilton Road, 3,700 feet alt., *Wood*, 9937; Umvoti, 3–4,000 feet alt., *Natal Herbarium*, 10801; Zwaartkop, 4,000 feet alt., *Wood*, 10142.

3. **H. dasycephalum** O. Hoff. Van Reenen's Pass, 5–6,000 feet alt., March, *Krook* (*Penther*, 1437).

4. **H. petiolatum** L. Insizwa, Umzimkulu, *Krook* (*Penther*, 1278); also in Cape Colony.

Ambrosia artemisæfolia L. Camperdown, 2,000 feet alt., *Miss Franks* in Herbarium *Wood*, 11660.

Tagetes patulus L. Umgeni, *Krook*, February (*Penther*, 1351). A native of Central America. Introduced into Natal.

Chrysanthemum nodosum Thb. Mt. Insiswa, Umzimkulwana, *Krook* (*Penther*, 1034); also in Cape Colony and Namaqualand.

Senecio adenophyton Schltr. and Musshler. Alexandra County, 1,800 feet alt., November, *Rudatis*, 455.

2. **S. longifolius** DC. Umkomanzi, February, *Krook* (*Penther*, 1456); also in Cape Colony.

3. **S. nudiusculus** DC. Van Reenen's Pass, 5–6,000 feet alt., March, *Krook* (*Penther*, 993); also in Cape Colony.

4. **S. oblongoideus** DC. Alexandra County, 1,800 feet alt., September, *Rudatis*, 711.

5. **S. Rudatisii** Schlechter and Musshler. Alexandra County, August, *Rudatis*, 687.

Euryops natalensis Schltr. and Musshler. Alexandra County, 1,800 feet alt., October, *Rudatis*, 449.

Dimorphotheca nudicaulis DC. Var. **latifolia** H. Van Reenen's Pass, 5–6,000 feet alt., March, *Krook* (*Penther*, 994).

Gazania Rudatisii Schltr. and Musshler. Alexandra County, October, *Rudatis* in Herb. *Wood*, 11962.

2. **G. subulata** R. Br. Fairfield, Alexandra County, 2,800 feet alt., *Rudatis*, 93.

Berkheya amplexicaulis O. Hoffm. Ixopo, February, *Krook* (*Penther*, 1385).

2. **B. onobromoides** DC. Between Estcourt and Colenso, February, *Krook* (*Penther*, 1051).

3. **B. stobeoides** Harv. and Sond. Van Reenen's Pass, 5–6,000 feet alt., March, *Krook* (*Penther*, 1441); also in Cape Colony, *Zeyher*, 982.

CAMPANULACEÆ.

Lobelia Ottoniana A. DC. Jolivet, 3,000 feet alt., October, *Rudatis*, 141.

Cyphia linarioides E. and Z. Alexandra County, 1,800 feet alt., October, *Rudatis*, 447; also in Cape Colony, February and March.

ERICACEÆ.

Erica Wyliei Bolus. Giant's Castle, Drakensberg, 9–10,000 feet alt., October, *Wylie* in Herbarium *Wood*, 10660.

SAPOTACEÆ.

Chrysophyllum viridifolium Wood and Franks. Berea, near Durban, 150–300 feet alt., January, *Wood*, 11636. A tree 30–50 feet high, not uncommon in woods near Durban, fruit 1¼ inch diam. not eatable. Wood hard and good.

OLEACEÆ.

Jasminium Wyliei N. E. B. 'Nkandhla, 4–5,000 feet alt., *Herb. Wood*, 8860. A large flowering species well worth cultivation.

APOCYNACEÆ.

Adenium swazicum Stapf. Swaziland, *Mrs. Rathbone* in Herbarium *Bolus*, 6208; Natal, Lebombo Mts., Zululand, *H. D. Jameson.* The plant was presented to the Botanic Gardens, Durban, by Mr. Jameson, where it flowered in January, 1912. (*See* "Natal Plants," vol. vi., pl. 600).

ASCLEPIADACEÆ.

Xysmalobium prunelloides Turcz. Jolivet, 3,000 feet alt., *Rudatis*, 139, October.

Schizoglossum decipiens N. E. B. Var. **flavum** N. E. B. Bushman's River Valley, 6,000 feet alt., *Wylie* in Herb. *Wood*, 11206.

Asclepias involucrata Schltr. Alexandra County, 1,800 feet alt., November, *Rudatis*, 458.

2. **A. reflexa** Schltr. Ellesmere, Alexandra County, 2,000 feet alt., November, *Rudatis*, 481.

3. **A. rivularis** Schltr. Ifafa, 2,500 feet alt., December, *Rudatis*, 191.

Sisyranthus compacta N. E. B. Alexandra County, 1,800 feet alt., December, *Rudatis*, 507.

2. **S. Franksæ** N. E. B. Amatikulu, Zululand, 2–400 feet alt., November, *Wood*, 11208.

Brachystelma Barberiæ Harv. Cedara, 3,500 feet alt., *Fisher* in Herb. *Wood*.

GENTIANEÆ.

Chironia humilis Gilg. Var. **zuluense** Prain. Ginginhlovu, Zululand, in Herb. *Wood*, 11355.

SCROPHULARIACEÆ.

Nemesia anfracta Hiern. Mt. Insiswa, *Krook* (*Penther*, 3004); Umgeni, January, February, *Krook* (*Penther*, 3005).

Halleria ovata Bth. Fairfield, Alexandra County, 2,800 feet alt., *Rudatis*, 24.

Sutera polyantha O. Kuntze. Van Reenen's Pass, 5–6,000 feet alt., March, *Krook* (*Penther*, 3024).

Limosella tenuifolia, Nutt. Van Reenen's Pass, 5–6,000 feet alt., March, *Krook* (*Penther*, 1883).

Rhamphicarpa serrata Klotsch. Alexandra County, 1,800 feet alt., January, *Rudatis*, 236.

Hyobanche sp. nov. Sea-beach, Karridene, August, *Wylie* in Herb. *Wood*, 11,002.

Scoparia dulcis L. Alexandra County, January, *Rudatis*, 614. A tropical plant introduced into Natal.

ACANTHACEÆ.

Thunbergia xanthotricha Lindau. Alexandra County, 1,800 feet alt., September, *Rudatis*, 707.

Dyschoriste trichocalyx Lindau. Alexandra County, 1,800 feet alt., September, *Rudatis*, 697.

Siphonoglossa sp., near **S. tubulosa**. 'Nkandhla, 4–5,000 feet alt., March, *Wylie* in Herb. *Wood*, 8875.

SELAGINEÆ.

Walafrida tenuifolia Rolfe. Colenso, 3–4,000 feet alt., *Krook* (*Penther*, 3079); Umgeni, February, *Krook* (*Penther*, 3080).

Selago Dielsii Rolfe. Alexandra County, 1,800 feet alt., April, *Rudatis*, 353.

2. **S. lepidioides** Rolfe. Ifafa, 2,500 feet alt., December, *Rudatis*, 182.

VERBENACEÆ.

Verbena Bonariensis L. Near Richmond, 3–4,000 feet alt., December. Introduced. Native of Brazil.

2. **V. tenera** Spreng. Edendale, November, *T. R. Sim.* Abundant according to Mr. Sim. Native of Argentine Republic.

LABIATÆ.

Becium obovatum N. E. B. Is **Ocimum obovatum** of former list.

Orthosiphon Bolusii N. E. B. Giant's Castle, Drakensberg, 9,000 feet alt., *Bolus* in Herb. *Guthrie,* 4894.

2. **O. Gerrardi** N. E. B. Rocky ground near Ingoma, *Gerrard,* 1239.

3. **O. latidens** N. E. B. Umvoti district, *Gerrard,* 1233.

4. **O. macrophyllus** N. E. B. Ingagane, Drakensberg, *Rehmann,* 7016; between Ingogo and Charlestown, 4–5,000 feet alt., *Wood,* 6398.

5. **O. Pretoriæ** Guerke. Near Newcastle, *Schlechter,* 3420; Glencoe, 4–5,000 feet alt., *Wood,* 4756; Zululand, *Gerrard,* 1219.

6. **O. teucriifolium** N. E. B. Table Mountain, *Krauss,* 448; grassy hill, Illovo, *Wood,* 1877; Curry's Post, 3–4,000 feet alt., *Wood,* 3567, December; Entumeni, Zululand, 2–3,000 feet alt., April, *Wood,* 3964.

7. **O. Wilmsii** Guerke. Near Durban, *Wood,* 8538; Pietermaritzburg, *Wilms,* 2189. This species is identical with **O. concinnus,** which is now a synonym.

Syncolostemon argenteus N. E. B. Inyezane, Zululand, May, *Wood,* 3875. This species is common as soon as the Tugela is crossed; not seen by us on the Natal side of the river.

Plectranthus Bolusii S. Cooke. Weenen County, April, *Wood,* 4488.

2. **P. Cooperi** S. Cooke. Byrne, 3,000 feet alt., in woods, April, *Wood,* 1843; without precise locality, *Gerrard,* 1673.

3. **P. densiflorus** S. Cooke. Mooi River, 3–4,000 feet alt., April, *Wood,* 4475.

4. **P. fruticosus** L'Herit. Edge of wood, 'Ngoya, Zululand, 1–2,000 feet alt., April, *Wylie* in Herb. *Wood,* 5751.

5. **P. Krookii** Guerke. Eisdumbini, 1–2,000 feet alt., April, *Wood,* 5398.

6. **P. nummularis** Briq. Indulindi, Zululand, 1,000 feet alt., April, *Wood,* 3980; 3981.

7. **P. pachyphyllus** Guerke. Without precise locality, *Rehmann,* 7878.

8. **P. Peglerae** S. Cooke, Zululand, *Gerrard,* 1235.

9. **P. transvaalensis** Briq. South Downs, Weenen County, 5,000 feet alt., December, *Wood,* 4378.

10. **P. Tysoni** Guerke. Dumisa, Alexandra County, *Rudatis,* 262.

11. **P. villosus** S. Cooke. Entumeni, 1–2,000 feet alt., April, *Wood*, 3955.

12. **P. Zuluensis** S. Cooke. *Gerrard*, 1675.

Coleus Pentheri Guerke. Byrne, 2–3,000 feet alt., March, *Wood*, 3199; "Thorns," Mooi River, 2–3,000 feet alt., April, *Wood*, 4340; without precise locality, *Gerrard*, 1237.

2. **C.** sp. Ungoye, Zululand, April, 1–2,000 feet alt., *Wood*, 5638. Cultivated by the natives.

3. **C.** sp. Camperdown, October, *Wood*, 5457; same locality, *Miss Franks* in Herb. *Wood*, 12011.

Salvia Cooperi Skan. *Cooper*, 1279; Southdowns, 4–5,000 feet alt., *Evans*, 389.

2. **S. Galpini** Skan. Southdowns, 4–5,000 feet alt., *Evans*, 391.

3. **S. monticola** Bth. Without precise locality, *Cooper*, 2888.

4. **S. repens** Burch. Buffalo Valley, 4–5,000 feet alt., January; Charlestown, 5–6,000 feet alt., November, *Wood*, 6245. In former list *Wood's* 5187 appears as **S. natalensis,** and *Wood's* 6245 as **S. triangularis.** Both these names must be erased, and those now given be retained.

5. **S. rudis** Bth. Between Umzimkulu and Umkomanzi Rivers, *Drege*, 4748.

7. **S. sisymbrifolia** Skan. Colenso, 3,300 feet alt., October, *Wood*, 4042; Ingoma, *Gerrard*, 1227.

8. **S. Tysoni** Skan. Drakensberg, near Charlestown, 5–6,000 feet alt., *Wood*, 7883; Zululand, *Gerrard*, 2031.

Acrotome hispida Bth. Without precise locality, *Gerrard*, 1229.

Stachys albiflora N. E. B. Drakensberg, 6–7,000 feet alt., *Evans*, 395.

2. **S. cymbalaria** Briq. Var. **alba** Skan. Near Richmond, 3,000 feet alt., *Wood*, 1846.

3. **S. erectiuscula** Guerke. Var. **natalensis** Skan. Newcastle, 3–4,000 feet alt., December, *Wood*, 6349; same locality, January, *Wood*, 6795.

4. **S. Galpini** Briq. Near Durban, *Grant*, *Peddie*; Weenen County, *Sutherland*.

5. **S. obtusifolia** McOwan. De Beer's Pass, 5–6,000 feet alt., March, *Wood*, 6029.

6. **S. parilis** N. E. B. Tiger Cave Valley, Drakensberg, *Evans*, 387.

7. **S. Rudatisii** Skan. Dumisa, Alexandra County, 2,000 feet alt., *Rudatis*, 405.

Leonotis dyssophylla Bth. Between Tugela and Klip Rivers, *Gerrard*, 393; Drakensberg, near Ladysmith, *Wilms*, 2111; Camperdown, 2,000 feet alt., *Rehmann*, 7750; Howick, 3–4,000 feet alt., *Junod*; *Drege*.

2. **L. intermedia**, Ldl. Var. **natalensis** Skan. Near Durban, *Peddie*; *Grant*; *Williamson*; Bushman's River, *Gerrard*, 362.

PLANTAGINEÆ.

Plantago longissima Dcne. Inanda, 1,800 feet alt., *Wood,* 1078. **P. Dregeana** of former list.

2. **P. remota** Lam. Damp ground, Mooi River, 3–4,000 feet alt., October, *Wood,* 4049.

NYCTAGINEÆ.

Boerhaavia bracteata S. Cooke. Natal, *Gerrard,* 1787 bis.

AMARANTACEÆ.

Achyranthes robusta C. H. Wright. Near Durban, *Wood,* 7202; Inanda, 1,800 feet alt., *Wood,* 4; without precise locality, *Gerrard,* 544.

CHENOPODIACEÆ.

Salicornia natalensis Bunge. Durban Bay, *Drege.*

POLYGONACEÆ.

Oxygonum alatum Burch. Near Maritzburg, 2,000 feet alt., *Bolus,* 10884.

2. **O. natalense** Schltr. Fairfield, Alexandra County, 2,400 feet alt., December, August, *Rudatis,* 1150; 74.

3. **O. subulatum** Baker. Fairfield, Alexandra County, 2,800 feet alt., *Rudatis,* 77.

Polygonum acuminatum Kth. Alexandra County, 1,800 feet alt., March, *Rudatis,* 330.

2. **P. strigosum** R. Br. Natal, *Dummer;* also in Tropical Africa and Australia.

Rumex Dregeanus Meisn. Near Durban, *Drege.*

2. **R. natalensis** U. Dam., sp. nov. Alexandra County, 1,800 feet alt., September, *Rudatis,* 722.

PIPERACEÆ.

Piper borbonense A. DC. Without precise locality, *Gueinzius;* also in Mascarene Islands.

Peperomia reflexa A. Dietr. Var. **capensis** C. DC. Without precise locality, *Gueinzius.*

2. **P. retusa** A. Dietr. Without precise locality, *Gerrard,* 1518.

LAURINEÆ.

Cryptocarya myrtifolia Stapf., sp. nov. Inanda, 1,800 feet alt., *Wood,* 1402; *Gerrard,* 1657. A large tree.

2. **C. Sutherlandii** Stapf., sp. nov. Bevaan River, 1–2,000 feet alt. July, *Wood*, 3388; stony places near Murchison (fruit only), April, *Wood*, 3033. The number 3083 in "Flora Capensis" is incorrect.

3. **C.** sp. nov. In former list is now **C. Wyliei** Stapf.

PROTEACEÆ.

Protea Flanagani Phillips. Polela, *F. C. Fernando* in Natal Herbarium, 9615; Karkloof, *Dr. Dimock Brown* in Natal Herbarium, 7537.

2. **P. multebracteata** Phillips. Near Durban, *Krauss;* Drakensberg, *Cooper*, 951.

3. **P. simplex** Phillips, sp. nov. *Sutherland;* without precise locality, *Gerrard*, 721.

4. **P. subvestita** N. E. B. Van Reenen, 5–6,000 feet alt., *Wood*, 5631; Mawahqua Mt., *Thode*, 47.

Leucospermum Gerrardi Stapf. Without precise locality, *Gerrard*, 721.

THYMELIACEÆ.

Gnidia calocephala Gilg. Alexandra County, 1,800 feet alt., September, *Rudatis*, 420.

LORANTHACEÆ.

Loranthus oleifolius Ch. and Schl. Ifafa, 1,500 feet alt., December, *Rudatis*, 537.

SANTALACEÆ.

Thesium racemosum Bernh. Alexandra County, 1,800 feet alt., November, *Rudatis*, 472.

EUPHORBIACEÆ.

Phyllanthus Gueinzii Mull. Arg. Glencoe, 4–5,000 feet alt., December, *Wood*, 5177.

Cluytia cordata Bernh. Fairfield, Alexandra County, 2,800 feet alt., *Rudatis*, 76.

Erythrococca berberidea Prain. Near Durban, 1–200 feet alt., *Wood*, 9489.

2. **E. natalensis** Prain. Mount Moreland, 50–100 feet alt.; Mount Edgecombe, 1–200 feet alt., November, *Wood*, 1089.

Macaranga Bachmannii Pax. Alexandra County, 1,800 feet alt., October, *Rudatis*, 746.

URTICACEÆ.

Celtis Soyauxii Engler. Near Durban, 2–300 feet alt., December *Wood*, 11726.

1. **Ficus dammarensis** Engl.

2. **F. Durbanii** Warb. Durban, July, *J. B. Davy* in Natal Herbarium, 12852.

3. **F. integrifolia** Sim. Bluff near Durban, *J. B. Davy* in Natal Herbarium, 12845.

4. **F. palustris** Sim. Durban, 50 feet alt., *J. B. Davy* in Natal Herbarium, 12848.

5. **F. Sonderi** Moq. Inanda, 1,800 feet alt., August, *Wood*, 1361; without precise locality, *Gerrard* and *McKen*, 1577.

6. **F. utilis** Sim. Near Durban, 100 feet alt., July, *J. B. Davy* in Natal Herbarium, 12846.

MYRICACEÆ.

Myrica conifera Burm. f. Alexandra County, 1,800 feet alt., May, *Rudatis*, 399.

MONOCOTYLEDONS.

ORCHIDACEÆ.

Eulophia acuminata Rolfe. Near Estcourt, 3–4,000 feet alt., December, *Wood*, 3428.

2. **E. Durbanensis** Rolfe. Near Durban, 100–200 feet alt., January, *Wood*, 11755.

3. **E. elegantula** Rolfe. Gillitts, 2,000 feet alt., September, *Wood*, 11789.

4. **E. foliosa** Bolus. Glencoe, 4,300, December, *Wood*, 5370; 263.

5. **E. gladioloides** Rolfe. Lidgetton, 3–4,000 feet alt., January, *Wood*.

6. **E. Haygarthii** Rolfe. Camperdown, 2,000 feet alt., January, *Wood*, 1960.

7. **E. Huttoni** Rolfe. Liddesdale, 5,000 feet alt., *Wood*, 4259; also without precise locality, *Wood*, 4202.

8. **E. inandensis** Rolfe. Indwedwe, 2,000 feet alt., July, *Wood*, 976.

9. **E. micrantha** Ldl. Umhlali, 30–50 feet alt., September, *Wood*, 11919.

10. **E. papillosa** Schltr. Near Verulam, 1,500 feet alt. (**E. chrysantha** Schltr. of former list).

11. **E. pergracilis** Rolfe. Near Howick, 3,400 feet alt., November, *Wood*, 11807.

12. **E. platypetala** Ldl. Alexandra County, 1,800 feet alt., *Rudatis*, 810.

13. **E. purpurascens** Rolfe. Tongaat, December, *Wood*, 434; Howick, 3,500 feet alt., Natal Herbarium, 700, *Wood*, 787.

14. **E. Saundersiæ** Rolfe.

15. **E. tenella** R. Br. Fairfield, Alexandra County, 2,000 feet alt., November, *Rudatis*, 172.

16. **E. triloba** Rolfe. Ginginhlovu, December, *Wood*, 11785.

17. **E. Wyliei** Rolfe. Ginginhlovu, December, *Wood*, 11783.

18. **E. Zeyheri** Hk. f. Ginginhlovu, December, *Wood*, 11780; Lidgetton, 4,000 feet alt., *Wood*, 7921; Inanda, 1,800 feet alt., *Wood*, 1070.

Angræcum pusillum Sw. Fairfield, Alexandra County, 2,800 feet alt., *Rudatis*, 31.

Nervilea purpurata Schltr. Ifafa, 1,800 feet alt., September, *Rudatis*, 714.

Platanthera bulbinella Schltr. Alexandra County, 3,000 feet alt., September, *Rudatis*, 577.

2. **P. ovata** Schltr. Fairfield, Alexandra County, *Rudatis*. **Brachycorythis ovata** of former list.

3. **P. tenuior** Schlechter. **Habenaria tenuior** of former list.

4. **P. Zeyheri** Schltr. *Rudatis*. **Schizochilus Zeyheri** of former list.

Pterygodium nigricans Schltr. Alexandra County, 1,800 feet alt., November, *Rudatis*, 463. **Corycium nigricans** of former list.

Neobolusia Tysoni Schltr. Boston, February, *Wood*, 5373.

SCITAMINEÆ.

Siphonochilus natalensis Wood and Franks. Inanda, 1,800 feet alt., *Wood*, 544; Zululand, 2–3,000 feet alt., *Wylie* in Herbarium *Wood*, 11723. Flowered in Botanic Gardens, Durban, December, 1910. (**Kæmpferia natalensis** of former list. "Natal Plants," vol. vi., pl. 560, 561).

IRIDEÆ.

Gladiolus Tysoni Baker. Alexandra County, 1,800 feet alt., *Rudatis*, 803.

Hesperantha leucantha Baker. Ifafa, 1,500 feet alt., December, *Rudatis*, 539.

Tritonia cinnabarinea Pax. Ifafa, 1,500 feet alt., February, *Rudatis*, 270.

AMARYLLIDEÆ.

Hæmanthus albiflos Jacq. Umtwalumi, 2,800 feet alt., March, *Rudatis*, 218.

LILIACEÆ.

Asparagus lilacinus Burch. Ginginhlovu, 1–200 feet alt., March, *Wood*, 9001.

Kniphofia Wyliei N. E. B. Entumeni, 2–3,000 feet alt., *Wylie* in Herb. *Wood*, 8996.

Aloe Marlothii A. Berg. Zululand, *Wood*.

Anthericum triflorum Ait. Alexandra County, 1,800 feet alt., November, *Rudatis*, 456.

LEMNACEÆ.

Wolffia denticulata Hegelm. Near Durban, probably in Umlaas River. Not seen by us.

CYPERACEÆ.

Cyperus macranthus Baeck. Alexandra County, 1,800 feet alt., September, *Rudatis*, 702.

2. **C. Papyrus** L. Zululand, September, *Stayner*.

Mariscus capensis Schrad. Cedara, 3,500, *Fisher*.

INDEX.

TIDAL PHENOMENA AT INLAND BOREHOLES NEAR CRADOCK.

By Andrew Young, M.A., B.Sc., F.G.S., F.C.S.

(Read June 19, 1912.)

(Plates III.–VI.)

In the following pages the terms "artesian well," "subartesian well," and "potential level" are used in the following sense :—

An artesian well is a bored well in which the water rises naturally to the surface of the ground and flows.

A subartesian well is a bored well in which the water rises above the level at which it was first encountered to a level within pumping reach of the surface.

The potential level of a well is the level at which the water stands when piped up as high as it will reach without recourse to pumps or siphons.

An artesian well might thus be described as a well whose potential level is above the level of the ground surface, and it will be observed that I do not use the term "artesian" as implying any particular theory of the origin of the water pressure.

During the last twenty years a large amount of boring for water has been carried on in the interior of Cape Colony. Very little was done in this direction previous to the year 1893. During the sixteen years, 1893 to 1909, the Cape Government subsidised water-boring enterprise to an extent probably unparalleled elsewhere in the world.

A very large Government water-boring establishment equipped with fifty to sixty drills of various types was gradually built up, and about half the cost of the work done was met by grants from the public exchequer. In connection with this expenditure of public money detailed records of most of the boreholes were carefully filed in the Government offices and generalised information based on these records was published in various Annual Reports of the Government Departments concerned in the work. During the later years of the period mentioned the policy of the Government was directed towards the reduction of the Government boring establishment and the encouragement of private boring contractors—the general object being the gradual cessation and final abolition of Government aid.

In 1910 the Government boring establishment was finally abolished, and the flourishing private boring industry that had sprung up was left to carry on the work on commercial lines. Information regarding the progress of boring since that date has necessarily become scanty and largely unreliable, as the detailed records are no longer filed in public offices.

The general results of the work of the Government drills from 1893 up to the beginning of 1910 are summarised in the Annual Report of the Public Works Department for 1909–10 as follows :—

Total number of holes bored by Government drills	5,596 holes
Total number of feet bored	405,355 feet
Number of holes in which water was found ...	4,326 holes
Number of holes yielding over 1,000 galls. per diem	3,856 holes
Estimated total yield of artesian or "flowing" water	18,663,944 galls. per day
Estimated total yield of subartesian water rising to within pumping reach	35,498,775 galls. per day
Estimated total yield of all holes	54,162,719 galls. per day

It will be seen from the first two lines that the average depth of these holes is only 72 feet, and as a matter of fact very few holes of over 500 feet have been made in Cape Colony. The few deeper holes have in most cases been unsuccessful. In the selection of sites for the boreholes various considerations have prevailed. The convenience of the farmer has often been the dominant consideration. In many cases a "dowser" has been employed by the farmer to select sites. In many other cases (probably about 50 per cent. of the whole) the farmer has left the selection of the sites to the Government official in charge of the drill. These drill foremen all obtained a little elementary instruction in geology mainly directed to enable them to recognise and trace the dolerite dykes which play an important rôle in the Karroo System, and they were instructed to avoid boring in dolerite but to select sites if possible within a few hundred yards of a dolerite dyke. This principle probably guided the majority of their selections.

The statistics published by the Chief Inspector of Water-Boring show that in general about 75 per cent. of the holes bored in the Karroo System were successful in yielding over 1,000 galls. of water a day. When rocks of pre-Karroo age were bored the percentage of success was much smaller.

The Reports further show that of the wells bored in the Karroo System about 25 per cent. yielded "flowing" or artesian water, while about 50 per cent. yielded subartesian water rising to within pumpable reach of the surface.

In nearly all cases in which water was struck the water rose in the borehole some distance above the stratum in which the water was first encountered.

During the last eight years a large number of holes have been bored in addition to these Government drillings. The Report of 1909 already quoted refers to the existence at that date of 102 private boring contractors in the Colony, and the Chief Inspector of Water-Boring in his Report for 1907 states that these boring contractors were putting down boreholes at the rate of 1,400 a year. As a rule these contractors bore only in the Karroo System or in localities where past experience has shown a considerable prospect of success. I estimate that altogether at the present day there must be over 10,000 successful boreholes in Cape Colony.

I have at various times visited a large number of these boreholes both during their construction and afterwards. It has become obvious to me that the vast majority of them merely tap shallow supplies dependent on the local rainfall, and that they are nearly all liable to give a diminished output or in some cases to dry up altogether after local droughts.

The temperature of most of these waters is approximately the same as the probable rock temperature within a few hundred feet of the surface. For purposes of irrigation the quantity of water yielded is, with few exceptions, insignificant, but for the purpose of watering stock and for domestic use these wells are of the utmost value to the country.

Practically the only attempt at a general theory of the artesian pressure, movement, and position of underground water in the Karroo System that has been hitherto recognised is what might be termed the "dolerite intrusion" theory.

This theory is fully explained in its various applications by Mr. H. P. Saunders in a Government Blue Book published in 1897 and entitled "Underground Water-supply of the Colony and the Cape of Good Hope." The substance of this theory is that the water enters the more pervious layers of Karroo sediments at their outcrops on elevated ground and percolates along these layers through pores and cracks to lower levels until stopped and dammed back by one of the numerous impervious dolerite intrusions. That underground dams of waterlogged rock are thus produced in which the water, under hydrostatic pressure, is held down by superincumbent shale or other impervious strata and held back horizontally by impervious dolerite dykes.

I have in the course of my wanderings seen much to support the opinion that this theory embodies a considerable amount of truth, but I have also come to the conclusion that it is far from containing the whole truth. Its application is confined to the obviously shallow local supplies of water, and it fails to meet the case of the few hot springs and hot-water wells that also occur in the Karroo System.

My observations have led me to hold the view that the waters of the Karroo System can be sharply divided into two great classes. On the one hand, those waters that are superficial in position, having variable temperatures of from 66 to 70° F. as in the vast majority of the boreholes and natural springs of the country; and on the other hand, those waters that are characterised by high temperatures of from about 75 to nearly 100° F., by the presence of sulphuretted hydrogen and methane gas, and generally also by the presence of a curious bacterium which flourishes in sulphurous waters. This deep-seated water is best known at a number of points where it emerges through natural springs, as at Aliwal North and Cradock.

As nearly all the boreholes extend to shallow depths, it has happened (as was to be expected) that very few have succeeded in tapping this deep-seated sulphurous water.

The happy accident of a shallow borehole having intersected a fissure leading down to great depths or a porous stratum fed by such fissures accounts for the few exceptions. Irregular fissures leading down to great depths also supply the only feasible explanation of the occurrence of such natural springs of thermal water as are seen at Aliwal North and Cradock.

When this contrast of the two classes of Karroo water had struck me, I began to feel that a careful study of the sulphurous occurrences would be most likely to lead to a better theory of the underground water of the Karroo, and my attention has since then been largely concentrated on that class, though intermittently, as the time at my disposal for such work was confined to infrequent long academic vacations, and each visit to the interior involved my spending three or four days in railway trains.

The position of the group of boreholes which I have studied in most detail is on a farm formerly called "Driefontein," but now known as "Tarka Bridge." It lies about 15 miles to the south-east of the town of Cradock, and on it the junction of the Tarka River and Fish River occurs. The arable land forming the greater portion of the farm lies between 2,700 and 2,800 feet above sea-level, while the mountainous portions on the south-east and east rise much higher—probably exceeding 4,000 feet in parts.

The geological structure of the farm is very simple. A series of shales and sandstones with a very slight northward dip and a few intrusive dykes and sills of dolerite are the principal features. The only fossil

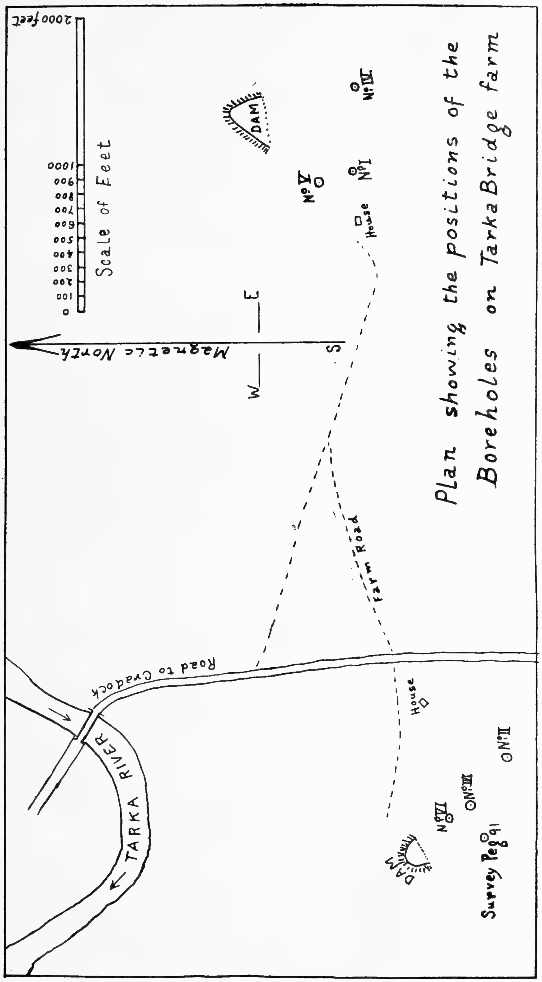

Plan showing the positions of the
Boreholes on TarkaBridge farm
Scale of Feet
0 100 200 300 400 500 600 700 800 900 1000
2000 feet
Magnetic North
W
E
S
DAM
DAM
No. I
No. II
No. III
No. IV
No. V
No. VI
House
House
Farm Road
Road to Cradock
TARKA RIVER
Survey Peg 91

FIG. 1.

which I found was a glossopteris impression on a fine-grained sandstone. The sedimentary series certainly belongs to the Karroo System, and the probability that it represents a horizon considerably lower than that of the reptile-bearing beds near Cradock may be inferred from the general direction of the dip.

The farm appears to have taken its old name " Driefontein " from the occurrence on it of three springs of warm sulphurous water which seem to have enjoyed a somewhat restrictedly local reputation of being beneficial to sufferers from rheumatism.

Since the present owners, Messrs. Rayner and Roberts, came into possession of the farm in 1903, eight boreholes have been made, six of which are situated in the vicinity of the natural springs. Five of these six have tapped supplies of sulphurous water which flows at the surface of the boreholes.

The boreholes are all of 6-inch diameter, and the following boreholes have been named as follows :—

No.	II.	is	204	feet deep
No.	III.	is	167	,,
No.	IV.	is	65	,,
No.	V.	is	65	,,
No.	VI.	is	225	,,

The sites of these boreholes are arranged in two groups: Nos. II., III., and VI. are within 185 yards of each other. Nos. V. and IV. are within 225 yards of each other and about 1,420 yards distant from the first group. (See Diagram 1.)

The aggregate yield of Nos. II., III., IV., and V. when they were first opened in 1903 was reported by the officers of the Government Public Works Department to be about 1,250,000 galls. per twenty-four hours. The initial yield, as is generally the case in this country, was not maintained, but continued to diminish for some time. This diminishing process appears to have nearly, if not entirely, ceased now, and a fairly constant yield to have been established. In the case of No. V., however, a periodic fluctuation of yield soon attracted the attention of the owners. In all five boreholes the water comes up accompanied by a large quantity of inflammable gas which bubbles out at the surface and smells strongly of sulphuretted hydrogen.

In the case of Nos. III. and VI. the escaping gas can easily be ignited by the mere act of throwing a burning match on the surface of the water as it escapes from the borehole. If the borehole has been closed for a quarter of an hour before the experiment the lambent flame from 1 to 2 feet high plays over the surface of the escaping water. By day the flame is bluish like that of a Bunsen burner, but by night the flame appears rather yellow (sodium flame), presenting a very weird appearance. The flame, after burning thus for a minute or two, is easily extinguished by the slightest puff of wind.

My personal observations of these boreholes began in Jauuary, 1905. About the end of 1904 I heard that Messrs. Rayner and Roberts had noticed a serious periodic variation in the apparent yield of borehole No. V. They said the variation was like a "tide," and although I was very sceptical about the propriety of this term as applied to the fluctuation, I thought this report was worthy of some inquiry.

In January, 1905, I spent a fortnight on the farm and made the following series of measurements.

1. *Temperature of the Water issuing from the Boreholes.*—The temperatures were observed on a maximum mercurial thermometer graduated in Fahrenheit degrees. Tenths of a degree were estimated by eye.

The National Physical Laboratory Certificate dated April, 1903, gives the correction at 72° and 82° as −0·1°.

In each case the mercury column was fully immersed in the water at the mouth of the borehole.

	Readings.	Corrected Readings.
Borehole No. II.	78·5° F.	78·4° F.
,, III.	81·0° F.	80·9° F.
,, IV.	77·6° F.	77·5° F.
,, V.	80·5° F.	80·4° F.

During the fortnight I frequently took readings of the temperatures at various hours of the day and night, but was unable to find any variations of temperature during that period. The various readings at any one borehole always agreed within $\frac{1}{10}$ of a degree, and a few discrepancies were clearly within the limits of observation error.

II. *Yield of the Boreholes.*—The yields of the four flowing wells were measured from time to time by allowing the water to flow into an iron vessel of $11\frac{1}{3}$ galls. capacity and determining by means of a stop watch the time occupied in filling the vessel.

The following were the readings obtained :—

Borehole No. III. on Jan. 27	at 6.50 p.m.	gave $11\frac{1}{3}$ galls.	in 13	sec.
28	10.0 a.m.	,,	13	,,
,,	11.35 a.m.	,,	13	,,
,,	2·55 p.m.	,,	13	,,
,,	7·0 p.m.	,,	13	,,

Borehole No. II. on Jan. 27	at 6.25 p.m.	gave $11\frac{1}{3}$ galls.	in 44	sec.
28	11.55 a.m.	,,	45	,,
,,	3.0 p.m	,,	44	,,
,,	6.55 p.m.	,,	45	,,

Borehole No. IV. on Jan. 28	at 9 a.m.	gave $11\frac{1}{3}$ galls.	in 45	sec.
,,	10.30 a.m.	,,	44	,,
,,	12.40 a.m.	,,	44	,,
,,	2.25 p.m.	,,	44	,,
,,	3.35 p.m.	,,	45	,,
,,	5.5 p.m.	,,	45	,,
,,	6.35 p.m.	,,	45	,,

Borehole No V.—

On Jan. 27 at	12 noon	gave $11\frac{1}{3}$ galls.	in 12	sec.	= 56·6	galls. per min.
,,	1 p.m.	,,	13	,,	= 52·3	,,
,,	5 p.m.	,,	15	,,	= 45·3	,,
28	8 a.m.	,,	17	,,	= 40·0	,,
,,	9 a.m.	,,	16	,,	= 42·5	,,
,,	10.30 a.m.	,,	14	,,	= 48·6	,,
,,	12.30 p.m.	,,	13	,,	= 52·3	,,
,,	2.20 p.m.	,,	13	,,	= 52·3	,,
,,	3.30 p.m.	,,	14	,,	= 48·6	,,
,,	5 p.m.	,,	$14\frac{1}{2}$	,,	= 46·9	,,
,,	6 p.m.	,,	15	,,	= 45·3	,,
,,	7.45 p.m.	,,	14	,,	= 48·6	,,
29	9.55 a.m.	,,	$16\frac{1}{2}$	,,	= 41·2	,,
,,	10.50 a.m.	,,	15	,,	= 45·3	,,

Thus it would appear that No. V. alone exhibits a notable variation in yield.

It will be observed that on January 28, between 8 a.m. and 8 p.m., the yield rises to a maximum in the neighbourhood of 1 p.m. and falls to a minimum about 6 p.m.

This No. V. borehole opened into the bottom of an iron tank about 2 feet square and 2 feet deep. An exit pipe of $5\frac{3}{4}$-inches internal diameter at the side of the tank conducted the water from the small tank A for a distance of about 15 feet into a larger and much deeper tank B. (See Diagram 2.) The water on emerging from this pipe had a drop of several feet through air before reaching the level of the water standing in B. A second exit pipe from the bottom of B led the water into a dam about 100 yards distant.

It was observed that the level of the water surface in the small tank A was always higher than the upper edge of the first exit pipe. This is easily intelligible when it is remembered that the water entered tank A through a vertical 6-inch diameter pipe and left by a 5¾-inch pipe, nearly horizontal, with a fall of only 3 inches in 15 feet.

As the level of the water surface was found to vary gradually, it occurred to me that a series of measurements of the height of this water surface would give an indication of the varying pressure at which the

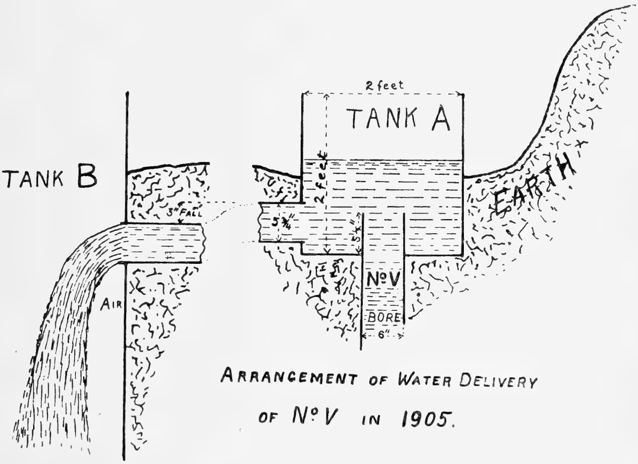


Fig. 2.

water issued from the top of the borehole into the tank, and so perhaps might afford a more delicate means of determining the variations in the yield. An arbitrary datum level was selected 18 inches beneath a certain point on the upper rim of the tank, and this datum level served as the zero of the following series of vertical measurements:—

On Jan. 28 at 8 a.m. the level of the water in tank A was 0·25 in. above datum.

,,	9 a.m.	,,	,,	0·81	,,
,,	10.45 a.m.	,,	,,	1·62	,,
,,	12.30 p.m.	,,	,,	2·12	,,
,,	2.15 p.m.	,,	,,	2·00	,,
,,	3.30 p.m.	,,	,,	1·75	,,
,,	5.0 p.m.	,,	,,	1·50	,,
,,	6.0 p.m.	,,	,,	1·25	,,
,,	6.30 p.m.	,,	,,	1·31	,,

Jan. 28	at 7.20 p.m.,	height of water-level	1·37	in. above datum	
,,	7.45 p.m.	,,	1·47	,,	
,,	9.10 p.m.	,,	1·67	,,	
,,	10.10 p.m.	,,	1·75	,,	
,,	11.5 p.m.	,,	1·97	,,	
29	12.10 a.m.	,,	2·12	,,	
,,	1.15 a.m	,,	2·12	,,	
,,	1.45 a.m.	,,	2·25	,,	
,,	2.25 a.m.	,,	2·00	,,	
,,	9.45 a.m.	,,	0·81	,,	
,,	10.0 a.m.	,,	1·00	,,	
,,	10.10 a.m.	,,	1·19	,,	
,,	10.25 a.m.	,,	1·37	,,	
,,	10.40 a.m.	,,	1·50	,,	
,,	10.50 a.m.	,,	1·69	,,	
,,	11.4 a.m.	,,	1·56	,,	
,,	11.20 a.m.	,,	1·75	,,	
,,	11.33 a.m.	,,	2·00	,,	
,,	11.53 a.m.	,,	2·06	,,	
,,	12.6 p.m.	,,	2·12	,,	
,,	12.25 p.m.	,,	2·19	,,	
,,	12.40 p.m.	,,	2·25	,,	
,,	12.55 p.m.	,,	2·44	,,	
,,	1.10 p.m.	,,	2·37	,,	
,,	1.25 p.m.	,,	2·44	,,	
,,	2.30 p.m.	,,	2·50	,,	
,,	3.40 p.m.	,,	2·37	,,	
,,	5.55 p.m.	,,	1·56	,,	
30	9.30 a.m.	,,	0·19	,,	
,,	9.45 a.m.	,,	0·22	,,	
,,	10.30 a.m.	,,	0·75	,,	

The highest part of the inner edge of the exit pipe was 0·31 in. below the datum line.

The curve obtained by plotting these measurements on squared paper like the curve of the yield shows a maximum on January 28 in the neighbourhood of 1 p.m. and a minimum about 6 p.m.

Further, it may be said to show in a general way in the course of a day and a half three maxima and three minima at roughly equal intervals of six or seven hours.

It was now apparent that the best means of obtaining further information about the periodic variation of yield would be some form of clock-driven, self-recording instrument registering the fluctuations of water-level in tank A. Accordingly further attempts to measure these variations were deferred until such time as the recording apparatus could be constructed.

Meanwhile I directed my attention to the question why No. V. should be exhibiting marked variation of yield while Nos. II., III., and IV. were nearly constant, showing little if any variation, although all four were giving forth high-temperature water with strong sulphurous odour and inflammable gas.

I closed both No. V. and No. IV. No. V. was closed by means of a wooden plug, through which a round hole was bored and a few feet of glass tube inserted to fit tight and stand in a vertical position. The water at once mounted in the glass tube to about 5 inches above the datum line, and then in the course of an hour slowly rose 7 inches higher.

Thus the *potential level* of No. V. is less than a foot above the level at which the water usually stands in tank A.

About an hour after the two boreholes had been closed No. IV. was opened again. Meanwhile I closely observed the water-level in the glass tube at No. V. The instant of opening No. IV. was signalled to me by Mr. Rayner by means of a gunshot. Exactly 60 seconds after I heard the shot I noticed the water-level in the tube shiver and drop about $\frac{1}{12}$ inch. Then it steadily dropped about $\frac{3}{8}$ inch per minute for a few minutes, after which the rate of fall diminished slightly. Twenty minutes after the first shiver the level had fallen about $4\frac{1}{4}$ inches in the tube.

It was clear then that No. IV. and No. V. had a close connection.

I failed, however, to obtain any evidence of a similar relationship between No. V. and the distant boreholes Nos. III. and II. I afterwards found that No. III. reacted to the opening or closing of No. II.

With a levelling instrument and surveyor's staff I next determined the relative heights of the boreholes to be as follows :—

Datum mark in water	at No. V. is	3·53 feet above level of No. IV.	orifice
,,	,,	6·70 feet above orifice of No. II.	,,
,,	,,	16·72 feet above orifice of No. III.	,,

More recently I have been able to relate these levels with sea-level as follows. The Government Irrigation Department has made a survey traverse in connection with a proposed irrigation furrow which was to be made through the farm. This traverse connects with the railway survey levels at Mortimer, which latter survey of course goes down to the coast at Port Elizabeth.

Peg 91 of the Irrigation Survey is situated within 100 yards of No. III., and on levelling from this peg I found that No. III. lies 8·95 feet lower.

On inquiry I find that Peg. 91 is 2,706 feet above railway level sea datum.

The borehole levels then become—

No. II.	2,707 feet above sea-level	
No. III.	2,697	„
No. IV.	2,710	„
No. V.	2,713·7	„

It has been already mentioned that the water of No. V. when piped upwards rose about a foot above the datum mark. This indicates an upward pressure of the water at the top of the borehole of less than ½ lb. on the square inch.

In the case of No. III. the pressure was much greater, and by closing that hole and balancing its pressure in a U-tube against a column of mercury I found that at first the pressure was equivalent to 10 inches of mercury column, rising during the first 5 minutes to 12·1 inches, and after 10 hours to 14·1 inches of mercury—a pressure of about 7 lbs. on the square inch. In other words, while the potential level of No. V. water was less than a foot above the borehole orifice, the potential level of No. III. was about 16 feet above the orifice. Incidentally we may also remark that the potential levels of No. V. and No. III. as thus determined were nearly the same, namely, 2,714½ and 2,713 feet above sea-level.

The foregoing data of relative levels and pressures seem to suggest a sufficiently plausible explanation for the comparative absence of very notable fluctuations in the yields of Nos. II. and III. The water of No. V. issues at so small a pressure that an increment of pressure amounting to an ounce or less on the square inch would naturally produce a noticeable effect, while a similarly small increment added to an already existing pressure of 6 or 7 lbs. on the square inch at No. III. might affect the yield there by an amount which might easily escape observation.

We also have the suggestion that if No. III. were piped up to the neighbourhood of its potential level it might be possible to detect fluctuations similar to those of No. V. Later it will be seen that this suggestion was carried out with results that confirmed the general truth of the above tentative reasoning.

On my return to Cape Town after my first visit to Tarka Bridge I had a self-recording instrument made there with such materials as I could find. Mr. Brackenbury Baily, of the Telegraph Department, kindly lent me a 4½-inch diameter revolving drum, with a fairly good spring-driven clock driving it through one revolution a day. Mr. W. H. Cottell, a highly skilled fine mechanic with the training of a chronometer maker, was at that time in the employment of the Public Works Department, and he carried out the construction of the machine under my direction.

The apparatus consisted of a large metal float firmly fixed to a vertical brass rod, the upper end of which was connected by a hinge joint to a horizontal brass arm lever of the first order about 19 inches long. At the end of the lever remote from the float was fixed a pencil, recording its vertical movement on the drum, which revolved on a vertical axis once a day.

The fulcrum support was placed near the middle of the lever. The pencil-point was found to be, as nearly as one could measure, 9 inches from the point of support, so that the pencil moved in an arc of a circle of

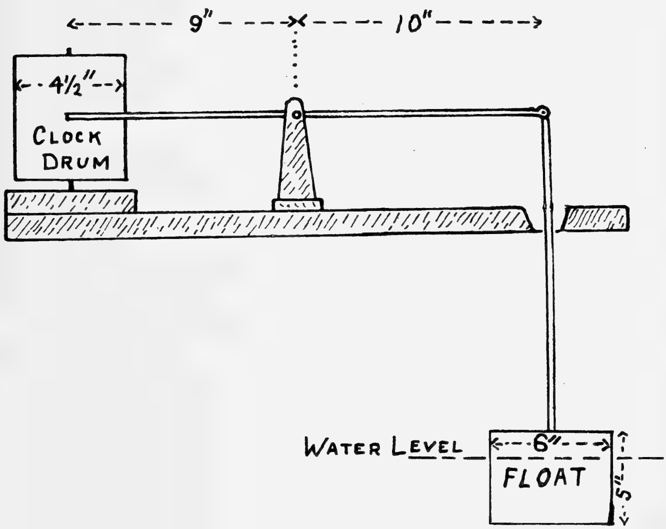


FIG. 3.

9 inches radius. The top of the float rod was found to be 10 inches from the point of support of the lever. Thus the actual vertical movement of the float was reduced on the record by about $\frac{1}{10}$ of its amount. As thus arranged an upward movement of the float was recorded by a downward movement of the pencil. The essential dimensions and general arrangement of the parts of the apparatus are exhibited in Diagram 3. The whole apparatus, with the exception of the float and part of the upright rod, was enclosed in a stout wooden box fitted with a plate-glass lid. A hole in the bottom of the box vertically under the hinge joint was fitted

with a thin brass collar, which served to keep the float rod vertical while effecting little frictional retardation of its vertical movements. When fixing the machine in position over the borehole care was taken to level the drum with a spirit-level, so as to ensure that its axis of rotation should be truly vertical.

As Messrs. Rayner and Roberts use the water of the boreholes for irrigation, and frequently have to regulate the flow to suit their requirements, it is only at certain limited periods that opportunities of using the recording apparatus occur.

The apparatus was fixed up over the small tank A at borehole No. V., and records were taken when opportunities occurred. The first long periods for which I obtained uninterrupted records were (1) the week May 22 to May 29, and (2) the fortnight June 4 to June 18, 1905.

During the taking of these records all the boreholes were closed except No. V., except for three occasions, on each of which No. IV. was opened temporarily for a few minutes. The effects of these temporary interferences are perfectly defined on the records, and make no trouble, as the normal course of the curve can be easily and satisfactorily interpolated owing to the very short duration of the perturbations.

Diagram 4 shows a tracing of the record sheet for the 24 hours' period 8 a.m. June 12 to 8 a.m. June 13. This record, besides showing the notch effect of one of the three interferences above mentioned, shows the general characteristics common to all the day records of the series. (See also curve A in Diagram 9.)

The most striking general feature of the curves obtained is their wonderful regularity. Each day record shows two maxima and two minima, and these turning-points occur at very regular and approximately equal intervals, as estimated by general inspection. By determining the times of the first and last maxima in the May week and dividing the time interval by the number of complete wave-lengths on the record, I quickly obtained a first approximate estimate of the average wave period as about 12½ hours. By a similar process the records for the June fortnight gave the same result.

On one side of the curve will be observed a large number of nearly vertical "hair" lines. Each of these "hair" lines records the escape of an unusually large gas-bubble, which on its arrival at the top of the borehole has impinged on the under surface of the float and caused a momentary upward jolt.

It is worthy of notice that in general the occurrence of these large gas-bubbles is much more frequent near the periods of high water than about low-water periods.

Another general feature of the records is the occurrence of a frill of minor fluctuations, with period varying from 5 to 20 minutes, and of an amplitude generally less than 2 millimetres. Occasionally also there appears here and there a wave-like movement of 3 or 4 millimetre amplitude and 1 or 2 hour period.

I have examined a number of records taken by the tide gauges at various points along the South African coast, and find that a frill of minor fluctuations of similar periods forms a characteristic feature of the marine tide curves, and I am given to understand that they are generally ascribed to marine seiche movements.

The amplitudes of the great $12\frac{1}{2}$-hour period waves were obviously subject to considerable variation. A general inspection brought to light the fact that these amplitudes attained a maximum of about $1\frac{1}{2}$ inches on June 17, which happened to be the date of full moon, and attained a minimum of less than $\frac{3}{4}$ inch about June 10, when the moon reached its first quarter. Another minimum was attained about May 26, when the moon reached its last quarter.

I had expected to find that variations of barometric pressure would exert an influence on the water-level in the tank A, and accordingly barograph records were taken on the farm simultaneously with the water-level records.

A comparison of the barograph records with the water-level records at first did not yield absolutely certain evidence of a connection between the two. During the June fortnight the barometric pressure remained very steady, and the barogram did not show any variation amounting to more than ·2 of an inch, and mere general inspection did not disclose any movements of the water-level curve that could be attributed to barometric change. During the May week, however, a greater variation of atmospheric pressure occurred, the barogram showing a gradual fall, extending through the greater part of the week, while the mean line of the water-level curve gradually rose during the same period. It was possible that this might have been a fortuitous coincidence, and it became obvious that much longer records would have to be secured if such a connection was to be established beyond doubt. Longer records would also be required to put on a more satisfactory basis the connection suggested above as existing between the great wave amplitudes and the lunar phases.

Messrs. Rayner and Roberts have from the beginning evinced a keen, intelligent interest in my investigations and a gratifying sympathy with the spirit of the inquiry. They have always been anxious to place all reasonable facilities and help at my disposal, but during these early years they were engaged in a very severe struggle with the difficulties of semi-arid farming. Their livelihood was dependent on their control of the water of these wells, and they were then unable to permit the uniformity of conditions necessary for the securing of a continuous record of two or three months. In particular they found it necessary from time to time to increase the yield of No. V. enormously by the insertion of a siphon. After the removal of the siphon the potential level recovered its normal position only after the lapse of days.

During the next two years I contented myself with occasional visits to the farm, during which I obtained a few short records of a day or two, which, with general observations, were sufficient to show that the fluctuations were apparently going on as before. I verified most of my earlier observations and examined the surface geology of the farm. The geological examination of the farm brought to light various facts which,

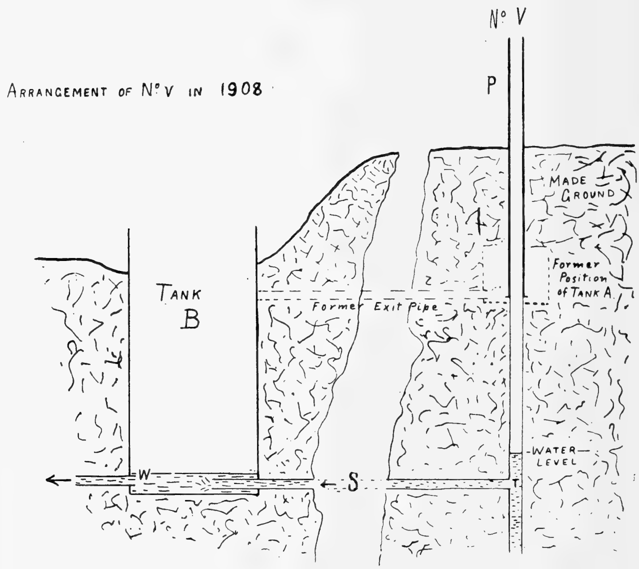


FIG. 5.

though interesting in other connections, did not seem to have any immediate bearing on the behaviour of the wells. The only observation that seemed to be worth mentioning in this connection was that the course of a dolerite dyke, prominently exposed on the mountains on the north boundary of the farm but hidden under the thick soil in the low ground, ran in a direction from a little east of north to a little west of south, in such a position as to indicate that its hidden portion probably passes between the two groups of boreholes.

During these years I observed no change in the temperatures of the waters.

Towards the end of 1907 Messrs. Rayner and Roberts informed me that they had made arrangements which would probably allow of a long record of several months' duration being taken during the early half of 1908.

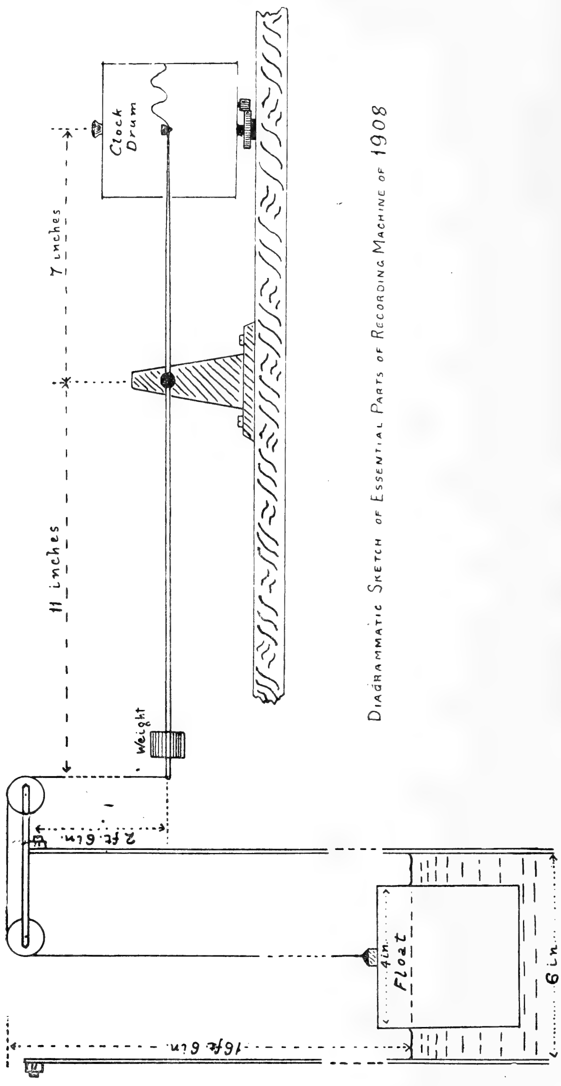
The arrangement for the delivery of the water from No. V. well, however, had now been entirely altered, and the old recording instrument could no longer be applied in the new conditions. On visiting the farm I found the altered state of affairs to be as follows. (See Diagram No. 5.) The old small tank A had been removed, and a few feet of iron piping *p* had been added to the former top of the 6-inch lining of the borehole. The top of this new pipe projected a few feet above the level of the ground. A new exit pipe *s*, lying almost horizontally, pierced the borehole lining at T about 7 feet below the former top of the borehole, and led the water directly into the bottom of the great tank B. The level of the water standing in the vertical pipe was always a few inches above the top of the horizontal exit pipe. The water flowed out of the tank B through the old opening at W, and so away down to the dam as before.

Measurements by means of a plumb-line showed that the water surface in the borehole was about 16½ feet beneath the top of the pipe P. I came to the conclusion that this water surface was probably still near enough to the potential level to allow of fluctuations being recorded, and a new recording machine was designed to fit the new conditions. (See Diagram No. 6.)

A recording drum of about 3·7 inch diameter was obtained from a barograph instrument. The clock in this drum caused one revolution per week An 18-inch brass rod lever was supported on a fulcrum pivot placed 7 inches from the writing end. Fixed to the end of the long arm of the lever was a length of silk fishing-line, which ran upwards, and after passing over two brass pulleys fixed to the top of the borehole pipe P, descended vertically within the pipe to the water-level, where it was attached to the float. It was found necessary to fix a small weight near the end of the long arm of the lever to ensure that the silk line should be always taut. Attached to the lower surface of the float by means of a few inches of brass chain was another metal weight, whose purpose was to steady the float and keep it in a position towards the centre of the horizontal section of the borehole.

It will be observed that a rise of the float was recorded by a rise of the pen on the drum record sheet. The whole instrument, except the silk line and float, was enclosed in a stout teak box with plate-glass lid, secured by means of a lock.

The silk cord emerged from the box by a small hole drilled in the wood



Diagrammatic Sketch of Essential Parts of Recording Machine of 1908

Fig. 6.

frame of the lid. The hole was so placed and of such a size as to ensure that the movements of the cord could never allow of any friction of the wood on the cord.

Mr. Cottell constructed the instrument, and as he was now stationed at Cradock he easily found opportunities of visiting the farm, setting up the instrument, and observing its behaviour.

As was to be expected, this second instrument did not work so smoothly as the simpler one of 1905. The increased friction due to the introduction of the pulleys partly accounted for this, and the weights on the lever and float required careful adjustment and balancing. The most advantageous balance of weights to use was found only after several unsuccessful trials. Mr. Cottell set up the instrument in the beginning of February, 1908, when I was also able to visit the farm for a day or two. The month of February was spent in attempts to reduce the friction and improve the working of the instrument. Mr. Cottell meanwhile sent me one by one such records as he obtained, together with his remarks on the action of the machine and his suggestions for mechanical improvement. By the beginning of March he reported to me that fairly satisfactory work could be expected.

From the beginning of March to the middle of June weekly record sheets were regularly obtained from the level recorder and from a barograph which I left on the farm. During all this period No. V. borehole was flowing uninterruptedly through the large tank into the dam, while the other boreholes on the farm were kept closed. Messrs. Rayner and Roberts assured me that during the four months they took the greatest care to ensure absolute uniformity of conditions as far as the human control of the boreholes was concerned. In the superior intelligence and trustworthiness of these gentlemen I have every reason to feel confidence. The records obtained, moreover, yield no evidence of any disturbance caused by other than natural causes.

Mr. Cottell undertook for me the general supervision of the instrument during the months February to June, paying frequent visits to the farm, and in his absence Mr. Rex Roberts undertook the weekly winding of the clocks and the weekly renewal of the record sheets. Mr. Cottell meanwhile posted weekly reports to me of the progress of the machine.

Mr. Roberts kept a careful record of the exact times at which each weekly record started and ended, and this, together with the lengths of the records afterwards measured by me, gave a means of estimating the average clock rates for each week.

The time as measured on Mr. Roberts's watch was compared with official railway time whenever any one on the farm made the journey to Mortimer Station or to Cradock. This communication with the railway takes place as a rule about once in every two days, but occasionally the flooding of the Fish River cuts off communication for four or five days. I have come to the conclusion that as a rule the railway time is known on the farm within 5 minutes, but that occasionally the error may have amounted to 20 minutes. Such occasional errors will, of course, be little appreciable on a record whose scale is such that 1 hour is represented by a length of curve amounting to $\frac{1}{20}$ inch.

Even after all efforts had been made to reduce the friction, the records gave evidence that much more friction remained than in the case of the 1905 machine. The upward and downward movement of the recording pen was often accomplished in a series of small jerks of about $\frac{1}{16}$ inch each, and occasionally of as much as $\frac{1}{4}$ inch. The machine was not sensitive to the larger gas-bubbles, and the general aspect of the line traced resembled the line traced by an ordinary barograph. There was little appearance of seich frill, and no hair lines due to impact of gas-bubbles on the float. Moreover, the machine did not seem to be capable of recording much of the semi-diurnal fluctuations when the amplitude was small—*i.e.*, about the times of moon's first and last quarters. The semi-diurnal fluctuations were clearly apparent, however, at all seasons of new and full moon, and thus one of the principal objects of taking the long record was successfully attained, as will be seen on Diagram No. 7, which is a photographic reduction of a tracing of all the records of these fifteen weeks.

The fifteen record sheets were fitted together in order, and carefully traced by me as a continuous record. The junctions of the original week records are indicated by vertical dotted lines.

The observed data from which the clock rate for each week was calculated is shown in Schedule VI. Each record was divided up into 24-hour periods in accordance with the estimated average clock rate for its week, and the curved ordinates drawn to indicate the position of 9 a.m. for each day. The clock rate was always very near 12 inches per week.

As the recording lever had been divided by the fulcrum pivot in the proportion of 7 : 11, the amplitudes of the fluctuations on the record were less than the actual water fluctuations.

Theoretically if the machine had been free of friction and backlash, and if the float had been perfectly sensitive to small variations of water-level, the mechanical reduction of the amplitudes would have left the recorded amplitudes in a scale of $\frac{7}{11}$ of nature. As a matter of fact the imperfections of the machine conspired to reduce the amplitude scale still further to an unknown extent.

The barograph records were obtained on a time scale of about 11 inches per week, but this scale is sufficiently near the time scale of the level records for purposes of general comparison. Accordingly the barograph curve for each week was traced under the water-level curve. I have also indicated by insertion of the usual conventional signs the times of the moon's phases during the fifteen weeks.

A comparison of the barograph and water-level curves shows very clearly and satisfactorily that (if we ignore the semi-diurnal fluctuations) the mean water-level line in general rises when the barometric pressure falls, and vice versa. Thus in the beginning of the first week the barometer falls and the mean water-level rises, while about the end of the week the barometer rises and the mean water-level falls.

In the second week, during March 10, 11, and 12, the barometer falls and the mean water-level rises. On March 13 and 14 the barometer is higher and the mean water-level correspondingly lower. During March 15 and 16 the barometer is lower and the mean water-level higher. This connection between the two lines obviously continues throughout most of the fifteen weeks, any marked rise or fall of the barometer being accompanied by a corresponding fall or rise of the mean water-level. The week from June 8 to June 15 appears to me to be noteworthy as being the only week in which the above rule seems to fail.

During June 10 and 11 the barometer shows a 24-hour period of high pressure without any obvious corresponding depression of the mean water-level, and on June 14 and 15 the mean water-level seems to be falling without any appearance of a barometric rise. It must be borne in mind that the barograph record is to be interpreted as indicating in a general way only the time of marked variations. I cannot regard its quantitative indications as being reliable within $\frac{1}{10}$ inch. This opinion is based on several weeks of daily comparisons which I have made of the indications of this barograph instrument with readings of a Kew mercurial barometer. I conclude, however, that the series of correspondences indicated on these fifteen weeks records is sufficiently notable and consistent to justify the belief that no theory of fortuitous coincidence will satisfactorily account for them, and that the records must be reasonably held to establish the general truth of the conclusion—

"*Increase of barometric pressure at Tarka Bridge is accompanied by a lowering of the general water-level in Borehole No. V., and vice versa.*"

An examination of the semi-diurnal fluctuations indicated on the water-level record shows that these fluctuations attain a maximum amplitude during the few days around each of the following dates: March 3, March 18, April 1, April 16, April 29, May 15, May 30, June 13, and that the amplitudes as recorded attain minimum and practically vanishing values in the neighbourhood of each of the following dates: March 8, March 25, April 8, April 23, May 8, May 22, June 6.

Now the Lunar Calendar for the period under consideration is as follows :—

1908.

● March 2, 6.57 p.m. (Greenwich)	● April 1, 5.2 a.m.
☽ March 9, 9.42 p.m.	☽ April 8, 4.32 p.m.
○ March 18, 2.29 a.m.	○ April 16, 4.55 p.m.
☾ March 25, 0.22 p.m.	☾ April 23, 7.7 p.m.
● April 30, 3.33 p.m.	● May 30, 3.15 a.m.
☽ May 8, 11.23 a.m.	☽ June 7, 4.56 a.m.
○ May 16, 4.32 a.m.	○ June 14, 1.55 p.m.
☾ May 23, 0·17 a.m.	

The inference from this comparison seems now to be well established to the effect that—

"*The semi-diurnal fluctuations of level in Borehole No. V. attain a maximum amplitude about the times of New Moon and Full Moon, and attain a minimum amplitude about the times of the Moon's quadratures.*"

A thermograph record of fluctuations of atmospheric temperature on the farm was also obtained for the fifteen weeks, but a comparison of these temperature curves with the water-level curves revealed no connection of any kind as existing between the two, and nothing further need be said of them.

Comparison of Tarka Bridge Records with South African Coastal Tide Gauge Records.

The elementary observations already described had shown the behaviour of Borehole No. V. to have an intimate relationship to the moon's position, and it now appeared advisable to compare the Tarka Bridge records with the coastal tide gauge records.

For this purpose I selected the record for the fortnight June 4 to June 18 of 1905. My reasons for selecting this record were the following :—

(*a*) This record was taken on the better machine of 1905.

(*b*) It is a record on a large time scale over half an inch to the hour, and allows of greater accuracy in determining the times of successive high and low water in the semi-diurnal fluctuations.

(*c*) It is the record for a fortnight in which little change of barometric pressure was recorded at Tarka Bridge, and thus the principal disturbing factor local to Tarka Bridge is nearly eliminated.

The daily record sheets of Tarka Bridge were first examined and the curved ordinates of 9-inch radius inserted at the beginning and end of each record. Then the straight lengths of records were measured and the average clock rates for each day determined. The following list gives the time at which each record was put on and taken off, together with the length of record afterwards measured, and the deduced clock rate.

LIST OF JUNE, 1905, RECORDS AT TARKA BRIDGE.

Put on at—	Taken off at—	Length as Measured.	Clock Rate Calculated.
9.30 a.m., June 4	8.20 a.m., June 5	33·81 cm.	1.48 cm. per hour
8.22 ,, 5	8.0 ,, 6	33·50 ,,	1·42 ,,
8.2 ,, 6	8.0 ,, 7	35·18 ,,	1·47 ,,
8.2 ,, 7	8.0 ,, 8	35.28 ,,	1·47 ,,
8.2 ,, 8	8.0 ,, 9	35.18 ,,	1·47 ,,
8.2 ,, 9	8.0 ,, 10	35·21 ,,	1·47 ,,
8.2 ,, 10	9.29 ,, 11	35·10 ,,	1·44 ,,
9.30 ,, 11	8.0 ,, 12	34·41 ,,	1·53 ,,
8.0 ,, 12	8.0 ,, 13	34·53 ,,	1·44 ,,
8.0 ,, 13	8.15 ,, 14	35·05 ,,	1·45 ,,
8.15 ,, 14	8.15 ,, 15	34·98 ,,	1·46 ,,
8.15 ,, 15	8.15 ,, 16	35·28 ,,	1·47 ,,
8.15 ,, 16	8.15 ,, 17	34·90 ,,	1·45 ,,
8.15 ,, 17	8.30 ,, 18	35·06 ,,	1·45 ,,

The total length of record for the fortnight is 4·54 meters, and the average clock rate for the fortnight is 1·46 centimeters per hour.

The high-water and low-water points on each day record were then determined as carefully as possible, and the times at which these points were attained estimated by means of the various time scales indicated by the above clock rates.

At the same time the vertical heights of each of these maxima and minima were measured on the records, the upper edge of the record sheet being used as the datum line in these vertical measurements. The record sheets had been cut to fit accurately to the edges of the revolving drum.

The accompanying Schedule I. contains a list of times and heights of all these maximum and minimum points for the fortnight.

Tide gauges of the Légé type (see figure in G. H. Darwin's "Tides and Kindred Phenomena," page 11) have been established for a considerable number of years at Cape Town, Port Elizabeth, East London, and Durban. By the courtesy of the respective Government engineers in charge of these gauges, I have been enabled to examine the automatic records of these instruments for the months of May and June, 1905, and I have measured on these records the times and heights of all the high and low water turning-points for the periods, during which I obtained simultaneous records at Tarka Bridge in 1905.

On these tide-gauge records the vertical scale is 1 inch to the foot of water-level movement, and the horizontal or time scale is 1 inch to the hour. The records are in monthly lengths of 60 or 62 feet each.

On Schedules II., III., IV., and V. are presented the results of my measurements on these curves for the period extending from June 3 to June 20, and these figures may be compared with those obtained from my June records at Tarka Bridge, and shown on Schedule I. In this connection it may be well to remark that the determination of the exact time of any individual high or low water point on a tide curve is by no means easy.

The curve in the neighbourhood of a turning-point is as a rule so flat that two observers might differ in their estimate of the time in some cases by as much as a quarter of an hour or even more. G. H. Darwin remarks (on page 223 of the work already cited) that if the water rises only about a foot from low to high water in the course of five hours it is almost impossible to say with accuracy when it was highest, and two observers might differ by half an hour or even by an hour. It must be borne in mind that whereas the difference in the coastal tide curves amounted to several feet the fluctuations of level on the Tarka Bridge records amounted only to an inch or two. Hence, while I am of opinion that my determinations of the time of turning-points on the coastal tide curves are in most cases accurate within a quarter of an hour, I cannot hope to have attained similar accuracy in the determination of the times of high and low water on the Tarka Bridge curve. Any individual determination may easily be in error by half an hour, and occasionally by an hour or even more. These errors, however, tend to disappear in the average periods calculated over the entire fortnight.

On Diagram No. 8 the data contained in the Schedules I., II., III., IV., and V. have been plotted in parallel lines to the same time scale, and this diagram exhibits the general similarity of the Tarka Bridge curve to the coastal tide curves.

The principal dissimilarities would appear to be—

(1) The scale of the semidiurnal amplitudes. These amplitudes in the Tarka Bridge curve range through a couple of inches, while in the coastal curves they range through several feet.

(2) The amplitude of the diurnal inequality seems to be relatively greater in the Tarka Bridge curve than in the coastal curves.

The following averages are easily calculated from the scheduled data.

From Schedule I.—

From first L.W. at 11.55 a.m., June 4,
to last H.W. at 8.0 a.m., June 18

is a period of 332 hrs. 5 min., and comprises 26½ wave-lengths. Average wave period at Tarka Bridge: 12 hrs. 32 min.

From Schedule II.—

From L.W. at 11 a.m., June 4,
to H.W. at 5.5 a.m., June 18

is a period of 330 hrs. 5 min., comprising 26½ wave-lengths on the tide curve. Average wave period at East London: 12 hrs. 28 min.

From Schedule IV.—

From L.W. at 10.31 a.m., June 4,
to H.W. at 4.25 a.m., June 18

is a period of 329 hrs. 54 min., comprising 26½ wave-lengths on the tide curve. Average wave period at Durban: 12 hrs. 25 min.

From Schedule V.—

From L.W. at 11.15 a.m., June 4,
to H.W. at 5.5 a.m., June 18

is a period of 329 hrs. 50 min., comprising 26½ wave-lengths on the tide curve. Average wave period at Cape Town: 12 hrs. 25 min.

The nearest point of the South African coast to Tarka Bridge is on the northern shore of Algoa Bay, and the distance is about 100 miles measured on a straight line. Port Elizabeth is about 114 miles from Tarka Bridge, and the distance between East London and Tarka Bridge is about 136 miles.

The East London tide gauge is the nearest one which was giving reliable records during the early half of June, 1905.

If we tentatively correlate the East London record with the Tarka Bridge record in such a way as to regard the East London high water of 4.55 a.m., June 4, as corresponding to the Tarka Bridge high water of 5.45 p.m. on the same day, and correlate all the remaining high waters consistently with this first assumption, we find that for the period June 4 to June 18 the average lag of Tarka Bridge high waters behind East London high waters is 14 hrs. 27 min., while a similar treatment of the low waters of the same period gives an average lag of Tarka Bridge low water behind East London low water amounting to 14 hrs. 51 min.

The difference in these two averages seems too great to be due to observational errors and raises a strong suspicion that the Tarka Bridge lag at low water is really greater than the lag at high water. Now if this is really so the curve records at Tarka Bridge will be slightly steeper when rising from low to high water than when falling from high to low water, and this is a matter which is easily investigated, the necessary data being contained in Schedule I.

If we take the difference of each time of low water as given in Schedule I. and the time of the succeeding high water we find that the average time interval between low water and the succeeding high water at Tarka Bridge is 5 hrs. 53 min. Then taking the time interval between each high water and the succeeding low water, we find the average interval to be 6 hrs. 35 min.

A comparative inspection of two sides of each individual wave represented in these lists of half-wave intervals makes the conviction stronger that we are here dealing with no imaginary phenomenon, for in the list of 27 ascending half-waves and 26 descending half-waves we see that in 20 individual cases the ascending half has a shorter interval than the descending half immediately following. In two cases the intervals are practically equal, and in the remaining four cases the ascending interval is greater than the descending interval. In each of the anomalous cases an inspection of the adjacent intervals strongly suggests that an unusually large error has occurred in the determination of the culminating point of the curve, and this would entirely account for the apparent anomalies.

I conclude that the inference is a fair one that in general a shorter time elapses between low water and high water than between high water and the succeeding low water of the well. In other words, at Tarka Bridge the water rises more quickly than it falls, and thus the rise and fall of this well water is to that extent analogous to the tidal fluctuations in an estuary or tidal river rather than to the tides in the open ocean. As will be seen later, this result is important as having a bearing on the questions arising as to the nature of natural mechanism by which the tidal influence is transmitted from the ocean to the well, if such a theory of the origin of Tarka Bridge tides be admissible.

The correlation of a particular high water on the coastal tide curve with a particular high water on the Tarka Bridge curve cannot be regarded as satisfactorily accomplished, and although in the foregoing discussion I have stated the lag of Tarka Bridge behind East London to be for high waters 14 hrs. 27 min., all I have really proved is that the lag is 14 hrs. 27 min. $+ p \cdot 12\frac{1}{2}$ hrs., in which expression p is a constant integer of undetermined positive or negative value.

It is indeed open to question whether such attempts at correlation are not from their very nature wholly illusory, since there is as yet no clear evidence that the Tarka Bridge tide is produced as a consequential effect of oceanic tides. The connection between the two may be merely that of a common astronomical cause.

Determination of the various Harmonic Periods in the Tarka Bridge Curve.

The advisability of subjecting the Tarka Bridge records to a harmonic analysis occurred to my mind at an early stage of my investigations.

On inquiring into the methods of harmonic analysis commonly adopted in the study of marine tide curves I found that these methods are based on assumptions that the curves consist of harmonic components the periods of which are known or assumed from astronomically observed data. As my object was to prove or disprove a definite connection between the harmonic components of the curve and astronomical data, I concluded that the above-mentioned methods were inapplicable for my purpose. Lately there came under my notice a method invented by Prof. Chrystal for the determination of the periods of the harmonic components of limnograms or seiche curves. This is a method which is based on no assumptions as to the nature of the causes producing the movements indicated on the curves, and a careful consideration of the mathematical theory of the method convinced me that it could be applied with perfect confidence to the Tarka Bridge records. Chrystal speaks of it as the "Method of Residuation," and its theory and mode of application is described fully in Trans. Roy. Soc., Edinburgh, vol. xlv., part 2, pp. 385–7. As this reference is not easily accessible to most South African readers, and as the method is little known, I venture to quote it in full in an Appendix.

From the form in which Chrystal gives his mathematical theory it may not be immediately obvious that the method is applicable to the Tarka Bridge curves, and the following explanation may perhaps be necessary.

Fourier has shown that any finite periodic function of a variable can be expressed as a series of terms, each of which is a simple harmonic function of this variable.

Thus if y be any periodic function of the time, y can by suitably choosing the constants A, M_1, M_2, &c., e_1, e_2, &c., be expressed by a series of terms as follows—

$$y = A + M_1 \sin (kt + e_1) + M_2 \sin (2kt + e_2) + \&c.$$

Without making any further assumptions as to the nature of the function this equation can be transformed into the form—

$$y = A_1 \sin \frac{2\pi}{T_1} (t - a_1) + A_2 \sin \frac{2\pi}{T_2} (t - a_2) + \&c.,$$

which is the equation for the curve assumed by Chrystal in his mathematical theory of the Residuation Process.

The method therefore is applicable to every curve which is the expression of a finite periodic function of a variable, and hence obviously to the Tarka Bridge records.

The residuation method is essentially a means of eliminating from a curve one by one its various harmonic components. My actual mode of working may be described as follows.

The curve to be residuated is traced on to another sheet, and then a second tracing of the same curve is superimposed on the same sheet but with the original curve moved along the time axis through a distance corresponding to half the period of the harmonic to be eliminated. Then a line is drawn so that it is everywhere half-way between the two tracings, and the intermediate curve thus obtained is the first residuum. It contains all the harmonic components of the original except one, with their periods unaltered but with their amplitudes considerably reduced.

I have found the process somewhat laborious in practice, but the results are much better than I had expected.

Residuation Method applied to Tarka Bridge Curve.

The same reasons already mentioned as leading to the selection of the record June 4 to June 18, 1905, for purposes of comparison with marine tide records held good in the consideration as to which of the Tarka Bridge records was most suitable for residuation analysis, and accordingly the record June 4 to June 18 was again selected.

The daily records for that period were fitted together and traced as a continuous curve on tracing cloth. This continuous record was almost 5 meters long. The tracing was made in the form of a smooth curve carried through a mean position in the seiche frills of the original. (This is the curve A at the top of the photo-reduced Diagram 9.)

The times of the first and last turning-points were determined as follows:—

First L.W. at 11.55 a.m., June 4,
Last H.W. at 8·0 a.m., June 18,

giving a period of 332 hrs. 5 min., comprising 53 half-waves of the dominant harmonic, or—

$$\frac{53T_A}{2} = 332 \text{ hrs. } 5 \text{ min.},$$

from which we deduce 12 hrs. 32 min. as a first approximation for the value of T_A.

The curve A was now residuated with respect to T = 12 hrs. 32 min., and yielded a curve C. This curve C was apparently composed of several harmonic components whose periods were very similar to each other, but one of these components had a considerably greater amplitude than the others. Attention was confined to this dominant component. By placing the eye near the level of the cloth at one end and glancing along the foreshortened curve, I was able to count 14 crests and 14 troughs in the curve.

I determined as nearly as possible the time positions of two or three of these turning-points near the beginning and end of the curve, and obtained the following results:—

(i) From 1st L.W. to 14th L.W. a period of 311 hrs. 59 min.

$$\therefore \quad T_C = \frac{311 \text{ hrs. } 59 \text{ min.}}{13} = 24 \text{ hrs.}$$

Owing to flatness of curvature and proximity to the beginning of the curve, the 1st H.W. is a badly defined point.

(ii) From 2nd H.W. to 14th H.W. is a period of 286 hrs. 17 min.

$$\therefore \quad T_C = \frac{286 \text{ hrs. } 17 \text{ min.}}{12} = 23 \text{ hrs. } 51\tfrac{1}{2} \text{ min.}$$

Taking the mean of these two values of T_C, we get for the period of the dominant harmonic of curve C as a first approximation the value 23 hrs. 56 min.

Returning to the original curve A and residuating it with respect to T = 23 hrs. 56 min., a second residual curve D was obtained. This curve D of course strongly resembled curve A, and, like it, showed 26 crests and 26 troughs. That curve D contained more than one harmonic component, however, was obvious from the fact that the amplitudes were smaller near the middle of the fortnight than near the beginning and end.

The times of the first and last H.W. and L.W. were determined, giving the following results:—

(i) From 1st L.W. to 26th L.W. was a period of 311 hrs. 41 min.

$$\therefore \quad T_D = \frac{311 \text{ hrs. } 41 \text{ min.}}{25} = 12 \text{ hrs. } 24 \text{ min.}$$

(ii) From 2nd L.W. to 26th L.W. was a period of 312 hrs. 0 min.

$$\therefore \quad T_D = \frac{312 \text{ hrs.}}{25} = 12 \text{ hrs. } 29 \text{ min.}$$

(iii) From 2nd L.W. to 26th L.W. was a period of 299 hrs. 33 min.

$$\therefore \quad T_D = \frac{299 \text{ hrs. } 33 \text{ min.}}{24} = 12 \text{ hrs. } 29 \text{ min.}$$

Averaging these three values, we get as a first approximation—

$$T_D = 12 \text{ hrs. } 27 \text{ min.}$$

This is of course really a second approximation to the value of T_A.

Again, returning to curve A and residuating it with respect to T = 12 hrs. 27 min., I obtained a residual curve F almost identical with the curve C already obtained.

On curve F the following results were obtained :—

(i) From 1st L.W. to 14th L.W. was a period of 311 hrs. 34 min.

$$\therefore \quad T_F = \frac{311 \text{ hrs. } 34 \text{ min.}}{13} = 23 \text{ hrs. } 58 \text{ min.}$$

(ii) From 2nd H.W. to 14th H.W. was a period of 286 hrs. 52 min.

$$\therefore \quad T_F = \frac{286 \text{ hrs. } 52 \text{ min.}}{12} = 23 \text{ hrs. } 54 \text{ min.}$$

(iii) From 3rd H.W. to 14th H.W. was a period of 263 hrs. 50 min.

$$\therefore \quad T_F = \frac{263 \text{ hrs. } 50 \text{ min.}}{11} = 23 \text{ hrs. } 59 \text{ min.}$$

Averaging these three values we obtain—

$$T_F = 23 \text{ hrs. } 57 \text{ min.}$$

This is of course really a second approximation to the value of T_C, and it thus appears that the limits of working accuracy were attained in the first residuation.

The curve F was next residuated with respect to its dominant harmonic period T = 23 hrs. 57 min., and yielded a curve H. No regular periodic undulation can be discerned on the curve H. By placing the eye near the level of the tracing cloth and glancing along the foreshortened curve, one distinguishes a fluctuation of irregular periodicity. Three crests and two troughs can be seen in the entire curve. As the curve is very flat and the undulation very long the positions of some of these turning-points can only be estimated with a probable error that might amount to nearly a day, while in the case of others the error might not exceed 6 hours.

The curve begins with a slight upward movement reaching a maximum about the afternoon of June 5 or the morning of June 6. Then it slowly declines to a minimum about the afternoon of June 7.

Next it slowly rises, attaining a maximum somewhere in the morning of June 9, after which it falls to a minimum in the morning of June 13.

Following this comes the most noteworthy movement of the curve. It rises more rapidly than usual, attaining the highest of all the maxima in the afternoon June 14, and remains very high from that point to the end in June 17, though a slight downward movement marks the last two days of its course. During June 14, 15, and 16 the line is continuously higher than in any other part of the fortnight.

It has been already remarked that the barograph curves taken on the farm during this fortnight indicated comparatively little variation of atmospheric pressure during the period.

A close examination shows that the barogram for the fortnight contains two principal maxima and three minima.

A slight downward movement begins in the morning of June 5, and a minimum is reached about 4 p.m. on June 6, after which a slight upward movement culminates in a maximum about 11 a.m. on June 7. Then a slight downward movement follows, reaching a minimum about noon on June 9, after which a gradual upward movement carries the curve to a maximum at 9 a.m., June 13.

Now follows the greatest movement of the fortnight. The line falls about ·2 of an inch between the last-mentioned time and the minimum at 6 p.m. of June 14. From that date on to the morning of June 18 there is little movement.

A comparison of the curve H with the barograph curve makes it apparent that the former is substantially the vertical inversion of the latter, the maxima of the one corresponding in time to the minima of the other.

Let us return now to the consideration of the residual curve D. Although this curve is obviously more uniformly regular than curve A, nevertheless it is apparent that it contains more than one harmonic component. This is indicated by the varying amplitudes of its waves. The obvious interpretation is that it consists of two harmonics whose periods do not differ much from each other—both being approximately semi-diurnal periods. In the middle of the fortnight when the amplitudes of curve D are smallest a minimum point of one of the harmonics synchronises with a maximum point of the other harmonic component. At the beginning and end of the fortnight when the amplitudes are greatest the maxima of the one harmonic tend to coincide with the maxima of the other harmonic. Now in the middle of the fortnight the moon was in its first quarter. One of the general results already obtained from the very long record of 1908 was the fact that amplitudes of the water-level curve are regularly at a maximum at the time of full and new moon and at a minimum during the moon's first and third quarters. This fact implies that the two principal harmonics in the curve have their respective maxima synchronising twice in a lunar month or once in 14 days. It follows from this that 14 days must be the least common multiple of the periods of the two harmonics.

The measurements already made on curve D have shown that its dominant harmonic period must be in the neighbourhood of 12 hrs. 27 min., or nearly $\frac{1}{27}$ of a fortnight. It now appears probable that it is exactly $\frac{1}{27}$ of a fortnight, or 12 hrs. 26 min., and that the remaining harmonic must either have a period of $\frac{1}{28}$ of a fortnight, or 12 hours, or alternatively $\frac{1}{26}$ of a fortnight.

In order to test the reliability of this last probable hypothesis in a practical way, the curve D was residuated with respect to T = 12 hrs., and in this way was obtained a residual curve F. This curve was composed of waves of small amplitude amounting on the average to about ·14 of an inch, and it was evident that in this residuation I was approaching the lower limits of accurate working. I determined 24 H.W. points and 25 L.W. points in the curve, and measured each wave interval both from L.W. to H.W. and also from H.W. to H.W.

In this way I found the average distance from H.W. to H.W. to be 18·16 cm., and the average wave-length as measured from L.W. to L.W. to be 18·15 cm.

Taking the average clock rate as 41·06 minutes per centimeter, and converting these averages into time, we get the values: 12 hrs. 25½ min., and 12 hrs. 25 min. This result, though not obtained by strict adherence to the Residuation process, at least shows that curve C is plausibly divisible into two harmonic components having periods of 12 hrs. 26 min. and 12 hrs. respectively. The possibility of its being equally divisible into another pair of components is not quite excluded.

Summary of the Results of the foregoing Analysis.

The record curve obtained at Tarka Bridge during the period June 4 to June 18, 1905, has been dissected into two curves having as their main harmonic periods

12 hrs. 27 min.,
and 23 hrs. 57 min. respectively,

together with an anharmonic residuum which appears to correspond substantially to a vertical inversion of the barogram for the fortnight obtained on the farm.

Further the curve of 12 hrs 27 min. periodicity has been shown to be plausibly divisible into two harmonic components having periods of 12 hrs. 26 min. and 12 hrs. respectively.

These results may be compared with the following principal harmonic components of marine tides (see "The Tides," by G. Darwin, p. 182).

I. Principal lunar semi-diurnal tide: Period, 12 hrs. 25 min. $14\frac{1}{6}$ sec.
II. Principal solar semi-diurnal tide: Period, 12 hours exactly.
III. Three diurnal tides: Periods, 23 hrs. 56 min.; 24 hrs. 4 min.; 25 hrs. 49 min. $9\frac{1}{2}$ sec.

The lunar periodicity of the well at least may be regarded as established.

Tidal Movements of Wells No. III. and No. VI.

In January, 1912, I spent a week on the farm and devoted my attention mainly to preliminary observations on Nos. III. and VI. I ascertained that Nos. II., III., and VI. had been continuously open for many months.

I closed Nos. III. and VI. by means of wooden plugs, through which projected tightly fitting lead tubes. These lead tubes projected vertically about 7 or 8 feet above the plugs, and were surmounted by lengths of glass tubing in which one could observe the rise of the water-columns to their potential levels. Arbitrary scales were attached to the glass tubes by means of which numerical values could be assigned to the levels of the water-columns in the tubes.

During the first few days the levels rose as the wells recovered the loss of potential due to their having been open so long. Then readings were taken during January 20 and 21.

The results plotted on squared paper indicate that the mean level continued to rise during these days, and that the process of recovery of lost potential was still continuously in progress. The theoretical "cone of depression" was still filling up around the well.

The curves, however, show in addition a distinct semi-diurnal fluctuation similar to that of No. V. in previous records. On January 21, between 6 and 7 p.m., No. VI. was opened for 14 minutes, and the effect of this is obvious on the No. III. record. This proves a close underground communication between No. III. and No. VI.

I determined the time interval for transmission of change of pressure between these two wells as 50 seconds.

Over No. II. there has been erected a windmill and pump, by means of which the water is raised and piped for domestic use into a tank on the roof of Mr. Roberts's house.

On January 22, about 6 p.m., this mill was put into action, vigorous pumping from No. II. began, and this at once began to effect a depression of the level on No. VI.

Thus it appears that Nos. II., III., and VI. have a more or less direct underground connection.

Arrangements are now being made to have an improved recording machine placed on No. VI. for the purpose of obtaining longer records. The short records already obtained suggest that the H.W. of No. VI. is not synchronous with that of No. V., and that there may be a time difference between the two amounting to several hours. Longer records, however, are necessary for the purpose of proving or disproving this want of synchronism. Various reports have reached me alleging the existence of fluctuations in several other sulphurous wells in the eastern part of Cape Colony, but I have not as yet had any opportunity of verifying them.

Analyses of the Water and Gas of the Tarka Bridge Wells.

A sample of the water which I took from No. V. in 1905 was analysed by Mr. John D. Rose, of the Government Analytical Laboratory. The following are Mr. Rose's analytical results :—

	In Grains per Gallon.
Total solids at 180° C.	38·80
Silica	1·78
Oxide of iron and alumina	0·06
Lime	3·82
Magnesia	1·23
Alkalies calculated as Na	13·67
Chlorine	13·79
Sulphuric oxide	0·33
Combined carbonic dioxide	5·33

"All the lime and magnesia are present as carbonates, with a trace of calcium sulphate, while sodium chloride appears to be the chief mineral constituent. The spectroscope reveals the presence of a very minute quantity of lithium. Potassium is also present in small quantities as shown by the flame reaction."

Mr. Rose did not attempt to estimate the dissolved gases, but part at least of the sulphuric oxide figuring in his analysis is probably due to oxidation of the sulphuretted hydrogen contained in the water as it issues from the well. The odour leaves the water after it has stood exposed to the air for a few hours. I have found that the water of all the Tarka Bridge wells tested on the spot immediately after collection, yields with cadmium chloride solution a considerable precipitate of yellow cadmium sulphide.

I have made various rough analyses of the gases escaping from the wells, showing that methane is the principal constituent in each case, and that oxygen and carbon dioxide are absent. A gas sample which I collected in January, 1912, from No. III. was analysed by Mr. James Moir, M.A., D.Sc., F.C.S., at Johannesburg, and yielded him the following results :—

Methane	94·0	per cent.
Hydrogen	2·7	„
Nitrogen and other unabsorbables	3·2	„
Oxygen and carbon dioxide—traces, together less than	0·1	„

I have observed various loose stones (some of them apparently showing signs of Bushman work) which seem to have been lying for a long time in the water escaping from the natural springs beside No. V. These stones are covered with a smooth siliceous enamel, and some of them with a smooth coating of iron pyrites. During the progress of a little excavation around the spring I also observed that the shales exposed were highly impregnated with small crystals of iron pyrites. The inference seems unavoidable that the sulphurous water deposits the iron pyrites from solution or by reaction of the sulphuretted hydrogen on the ferruginous constituents in the shales.

The bacterium already alluded to is present in all the five boreholes and in the natural springs associated with them. It appears as white or pink feathery loose tufts, which from time to time are emitted in the escaping water. On exposure to the air and sunlight these tufts soon become dark in colour. I submitted specimens to my colleague Professor Pearson, South African College, and he informs me that it is a sulphur bacterium which flourishes in water impregnated with sulphuretted hydrogen. I have observed similar tufts issuing with the water of the sulphurous springs of Cradock and Aliwal North.

As the quantity of gas delivered by the boreholes I have no very definite data. Nos. III. and VI. seem to be the holes which are most prolific in gas, but the rate of gas discharge obviously varies much in all the wells. On several occasions I inserted a 6-inch funnel in inverted position into the borehole, and so collected most of the escaping gas as it issued from the thin end of the funnel. The gas was led through a pipe into a 3-litre bottle, from which it easily displaced the contained water. I noted the time taken to fill the bottle with gas. The results indicated that No. III. and No. VI. each delivered from 3 to 4 litres of gas per minute. Messrs. Rayner and Roberts state that the rate of gas delivery as estimated roughly by the apparent trouble of the water surface is considerably affected by changes of weather, and that they obtain predictions of approaching storms in this way. It seems probable that great falls in the barometric pressure would increase the rate of gas delivery, by allowing the expansion and partial escape of quantities of gas partially imprisoned in underground branch fissures with low outlets communicating with the main fissures forming the water pathways.

Summary.

Observations begun in 1905 and carried on at intervals until the present year on a group of wells on a farm at Tarka Bridge, Cradock District, are described in detail.

The wells have not been bored very deep, the deepest being 225 feet, but it is obvious that the bores connect with deeply extending fissures, as the waters issue at temperatures of about 80° accompanied by large quantities of natural inflammable gas (methane), while sulphuretted hydrogen is present in notable quantities in solution in the water. The wells are 2,700 feet above sea-level and over 100 miles from the coast.

Measurements of the pressure at which the water issues show a remarkable fluctuation, in some respects analogous to the tidal fluctuations of the sea.

A series of direct measurements covering several days established the fact that there was a real fluctuation both in the amount of water discharged and in the well-pressure. Continuous records were then obtained over longer periods by means of clock-driven, self-recording apparatus in order to study the precise nature of the fluctuations.

The longest continuous record obtained extends over a period of fifteen weeks. This graphical record shows that the semi-diurnal fluctuations attain a maximum amplitude at fortnightly intervals at times corresponding to the times of new moon and full moon throughout the fifteen-weeks' period.

This record further demonstrates the fact that the mean daily water pressure rises with each fall of barometric pressure, and falls with each rise in barometric pressure as recorded concurrently at the farm by means of a barograph instrument. The time scale on this fifteen-week record is about 11 inches per week.

Records obtained for shorter periods on a time scale of 13½ inches per day were found to be much more suited for detailed critical examination and analysis. In particular, the record for a certain fortnight during which the barometric pressure was very steady (and consequently its interfering effect almost negligible) was selected. The times of all the turning-points were carefully determined in terms of South African official time. The heights of all the turning-points of the curve were also determined in inches.

Similarly, the co-ordinates of all the turning-points for that fortnight were determined on the tide gauge records of the South African ports of Cape Town, Port Elizabeth, East London, and Durban.

For general comparison all these measured data were plotted in parallel lines on the same time scale, and the general resemblance of the well curve to the curves of the coastal tide records demonstrated.

The original Tarka Bridge record for the fortnight was then subjected to a process of harmonic analysis for the purpose of determining the periods of the principal harmonic components of the curve. The particular method used was described by Chrystal as the method of " Residuation " (Trans. Roy. Soc., Edinburgh, vol. xlv., part 2, pp. 385–7). This method is applicable to comparatively short curves and involves no assumptions as to periods or the causes operating to produce the curve. One by one the various simple harmonic components are disentangled from the compound curve with their periods unaltered but with their amplitudes considerably reduced.

In this way components were isolated from the Tarka Bridge curve having the following wave periods :—

1. 12 hrs. 27 min. [probably divisible into 12 hrs. 26 min. and 12 hrs. 0 min.]
2. 23 hrs. 57 min.
3. An anharmonic residuum which appeared to be the vertical inversion of the barograph curve for the fortnight.

Component No. 3 was obviously not a simple harmonic function. It was apparently composed of several harmonics of approximately diurnal period, but on the scale on which the analysis was being conducted the practical limit of the method had been reached. Accordingly no finer dissection was attempted.

The above results may be compared with the well-known principal harmonic components of marine tides.

1. Principal Lunar semi-diurnal tide—period 12 hrs. 25 min. $14\frac{1}{6}$ sec.
2. Principal Solar semi-diurnal tide—period 12 hrs.
3. Three diurnal tides with periods—23 hrs. 56 min.; 24 hrs. 4 min.; 25 hrs. 40 min. $9\frac{1}{2}$ sec.

General Remarks.

The foregoing results seem to establish beyond question that the fluctuations in these wells are to be attributed directly or indirectly to extra-terrestrial causes, but the precise nature of the connection is not by any means clear.

The wells are situated over 160 miles from the coast, at an altitude of over 2,700 feet above sea-level. High water at Tarka Bridge occurs about $14\frac{1}{2}$ hours after high water at East London, while the lag in the case of low water is nearly 15 hours.

The principal conceivable theories to account for the phenomena would appear to group themselves in three classes:—

A. Theories depending on the direct gravitative influence of the sun and moon on the land or the underground water.

B. Theories depending on the action of the marine tides on the coast loading and distorting the land.

C. Theories depending on the action of marine tides in periodically reducing the freedom of outflow of underground water through submarine springs.

No attempt is at present made to state or discuss these theories. It is felt that a satisfactory theory can be arrived at only by the co-operative discussion of the subject by astronomers, geologists, and hydraulicians.

Tidal wells are known in many parts of the world, but practically all are within 3 or 4 miles of the seashore and at no considerable altitude. The records from the Orisino Bore in Australia do not show the periodicity of marine tides.

One case is reported at Lille in France, 40 miles from the coast, but at no great height above sea-level. The evidence supporting the tidal claim of this well is far from satisfactory.

It is believed that there is no other record of an inland well showing fluctuations of true lunar periodicity.

SCHEDULE I.

MEASUREMENTS OF TURNING-POINTS ON WATER-LEVEL RECORDS ON BOREHOLE NO. V. "TARKA BRIDGE," JUNE, 1905.

High Water.			Low Water.		
Date.	S.A. Time.	Height.	S.A. Time.	Height.	Date.
		Inches.		Inches.	
			11.55 a.m.	2·10	June 4
June 4	5.45 p.m.	3·01	1.10 a.m.	1·49	,, 5
,, 5	6.55 a.m.	3·12	1.10 p.m.	2·25	
	6.0 p.m.	3·19	1·10 a.m.	2·00	,, 6
,, 6	7.25 a.m.	3·36	2.15 p.m.	2·39	
	7.25 p.m.	3·03	2.40 a.m.	1·94	,, 7
,, 7	9.0 a.m.	3·10	3.0 p.m.	2·34	
	8.20 p.m.	2·96	3.25 a.m.	1.99	,, 8
,, 8	11.2 a.m.	2·83	4.56 p.m.	2·35	
	10.32 p.m.	3·02	4.10 a.m.	2·38	,, 9
,, 9	10.50 a.m.	3·16	5.40 p.m.	2·29	
	11.45 p.m.	2·78	5.50 a.m.	2·12	,, 10
,, 10	12.56 p.m.	3·13	8.22 p.m.	2·21	
,, 11	2.25 a.m.	2·88	8.51 a.m.	2·22	,, 11
	1.25 p.m.	3·18	8.0 p.m.	2·13	
,, 12	2.30 a.m.	3·03	8.40 a.m.	2·19	,, 12
	2.15 p.m.	3·01	9.10 p.m.	1·94	
,, 13	3.30 a.m.	2·93	9.20 a.m.	2·00	,, 13
	3.10 p.m.	3·06	10.0 p.m.	1·91	
,, 14	4.10 a.m.	3·38	10.56 a.m.	2·50	,, 14
	4.18 p.m.	3·58	12.2 a.m.	1·96	,, 15
,, 15	5.37 a.m.	3·27	11.10 a.m.	2·21	
	4.30 p.m.	3·22	11.40 p.m.	1·78	
,, 16	7.0 a.m.	3·50	11.52 a.m.	2·52	,, 16
	5.5 p.m.	3·35	12.3 a.m.	1·63	,, 17
,, 17	6.43 a.m.	3·06	12.10 p.m.	2·11	
	5.45 p.m.	3·21	12.45 a.m.	1·70	,, 18
,, 18	8.0 a.m.	3·27			

Heights measured from Arbitrary Datum Line being upper edge of Record Sheets which were cut to fit accurately to the edges of the revolving drum.

Times are expressed in South African Civil Time (2 hours E. of Greenwich).

SCHEDULE II.

Data Measured on East London Tide Gauge Record, June, 1905.

High Water.			Low Water.		
Date.	S.A. Time.	Height.	S.A. Time.	Height.	Date.
		Feet.		Feet.	
June 3	4.25 a.m.	5·20	10.35 a.m.	1·08	June 3
	4.50 p.m.	5·15	10.35 p.m.	1·35	
,, 4	4.55 a.m.	5·28	11.0 a.m.	1·17	,, 4
	5.25 p.m.	5·41	11.15 p.m.	1·50	
,, 5	5.35 a.m.	5·43	11.35 a.m.	1·35	,, 5
	6.5 p.m.	5·52	11.45 p.m.	2·06	
,, 6	6.20 a.m.	6·00	12.15 p.m.	2·21	,, 6
	6.25 p.m.	5·98	12.30 a.m.	2·24	,, 7
,, 7	6.45 a.m.	5·43	1.0 p.m.	1·75	
	7.20 p.m.	5·30	1.15 a.m.	2·22	,, 8
,, 8	7.35 a.m.	5·17	1.35 p.m.	2·03	
	8.0 p.m.	5·10	2.20 a.m.	2·41	,, 9
,, 9	8.40 a.m.	4·86	2.35 p.m.	2·33	
	9.15 p.m.	4·89	3.35 a.m.	2·49	,, 10
,, 10	9.50 a.m.	4·47	3.40 p.m.	2·44	
	10.30 p.m.	5·00	4.50 a.m.	2·61	,, 11
,, 11	11.15 a.m.	4·61	5.10 p.m.	2·72	
	11.55 p.m.	5·28	6.30 a.m.	2·65	,, 12
,, 12	12.40 p.m.	4·94	6.20 p.m.	2·80	
,, 13	12.55 a.m.	5·52	7.15 a.m.	2·27	,, 13
	1.35 p.m.	5·12	7.40 p.m.	2·21	
,, 14	1.45 a.m.	5·48	8.10 a.m.	1·60	,, 14
	2.35 p.m.	4·98	8.25 p.m.	1·60	
,, 15	2.45 a.m.	5·57	9.0 a.m.	1·38	,, 15
	3.15 p.m.	5·30	9.10 p.m.	1·47	
,, 16	3.25 a.m.	5·65	9.40 a.m.	1·23	,, 16
	4.20 p.m.	5·63	9.50 p.m.	1·51	
,, 17	4.25 a.m.	6·00	10.30 a.m.	1·59	,, 17
	5.0 p.m.	6·31	10.40 p.m.	2·01	
,, 18	5.5 a.m.	6·41	11.5 a.m.	1·66	,, 18
	5.25 p.m.	6·12	11.20 p.m.	1·79	
,, 19	5.45 a.m.	6·07	11.45 a.m.	1·78	,, 19
	6.10 p.m.	6·06	12.10 a.m.	1·83	,, 20
,, 20	6.15 a.m.	5·39	12.25 p.m.	1·24	
	6.45 p.m.	5·08	12.40 a.m.	1·52	,, 21
,, 21	6.55 a.m.	4·72	12.55 p.m.	1·25	
	7.25 p.m.	4·75			

Heights measured from East London Harbour Datum Mark.
Times are all South African Civil Times (2 hours E. of Greenwich).

SCHEDULE III.

DATA MEASURED ON PORT ELIZABETH TIDE GAUGE RECORD, JUNE, 1905.

High Water.			Low Water.		
Date.	S.A. Time.	Height.	S.A. Time.	Height.	Date.
		Feet.		Feet.	
June 4	4.36 a.m.	4·81	10.26 a.m.	−0·33	June 4
			*7.47 p.m.	−0·10	June 14
June 15	*2.20 a.m.	4·88	8.34 a.m.	−0·04	,, 15
	2.43 p.m.	4·74	8.27 p.m.	+0·11	
,, 16	2.55 a.m.	5·54	9.4 a.m.	0·41	,, 16
	*3.21 p.m.	5·75	9.3 p.m.	0·88	
,, 17	3.27 a.m.	6·07	10.21 a.m.	0·65	,, 17
	4.8 p.m.	5·46	10.18 p.m.	0·27	
,, 18	4.22 a.m.	5·38	*10.46 a.m.	0·24	,, 18
	*5.44 p.m.	5·00	10.54 p.m.	0·68	
,, 19	4.45 a.m.	5·56	11.0 a.m.	0·16	,, 19
	5.18 p.m.	4·85	11.45 p.m.	0·02	
,, 20	5.30 a.m.	4·27	11.43 a.m.	−0·21	,, 20
	6.14 p.m.	4·41			

NOTE.—The record for the ten days succeeding June 4 was quite unreliable owing to instrument being out of order.

At the points marked * the record also shows evidence of some instrumental friction or minor disturbance.

Heights are measured from P.E. Harbour Datum Mark.

Times are South African Civil Times (2 hours E. of Greenwich).

SCHEDULE IV.

Data Measured on Durban Tide Gauge Record, June, 1905.

High Water.				Low Water.			
Date.	S.A. Time.	Height. Ft.	Height. In.	S.A. Time.	Height. Ft.	Height. In.	Date.
June 2	3.34 a.m.	6	0	9.37 a.m.	1	3	June 2
	3.55 p.m.	5	10	9.36 p.m.	1	2	
,, 3	3.52 a.m.	6	2½	10.2 a.m.	0	9½	,, 3
	4.23 p.m.	6	0	10.8 p.m.	0	10½	
,, 4	4.20 a.m.	6	1	10.31 a.m.	0	8	,, 4
	4.48 p.m.	5	10	10.40 p.m.	0	9	
,, 5	4.58 a.m.	5	9	11.12 a.m.	0	5	,, 5
	5.23 p.m.	5	7½	11.9 p.m.	0	10	
,, 6	5.30 a.m.	5	9½	11.35 a.m.	0	10	,, 6
	5.47 p.m.	5	10½	11.57 p.m.	1	1	
,, 7	6.8 a.m.	5	5½	12.22 p.m.	0	10½	,, 7
	6.27 p.m.	5	5	12.25 a.m.	1	3	,, 8
,, 8	6.52 a.m.	5	1	12.56 p.m.	1	2	
	7.23 p.m.	5	3	1.36 a.m.	1	8½	,, 9
,, 9	7.35 a.m.	4	11	1.50 p.m.	1	8	
	8.15 p.m.	5	1½	2.27 a.m.	2	0½	,, 10
,, 10	8.41 a.m.	4	8½	2.53 p.m.	2	0	
	9.34 p.m.	4	9	3.32 a.m.	1	11	,, 11
,, 11	9.52 a.m.	4	2	4.27 p.m.	1	8	
	11.27 p.m.	4	7½	5.32 a.m.	1	5½	,, 12
,, 12	11.47 a.m.	4	1½	5.47 p.m.	1	4	
,, 13	12.11 a.m.	4	8½	6.37 a.m.	0	11½	,, 13
	1.0 p.m.	4	4	7.5 p.m.	0	10	
,, 14	1.16 a.m.	5	3	7.46 a.m.	0	10	,, 14
	2.0 p.m.	5	2	7.57 p.m.	1	0	
,, 15	2.16 a.m.	6	1	8.30 a.m.	1	0½	,, 15
	2.50 p.m.	5	10½	8.37 p.m.	0	11	
,, 16	3.2 a.m.	6	3½	9.3 a.m.	0	7½	,, 16
	3.38 p.m.	5	11½	9.32 p.m.	0	5	
,, 17	3.49 a.m.	5	11½	10.7 a.m.	0	1	,, 17
	4.12 p.m.	5	9½	9.47 p.m.	0	2½	
,, 18	4.25 a.m.	5	10	10.23 a.m.	0	1	,, 18
	4.43 p.m.	5	10	10.46 p.m.	0	3	
,, 19	4.58 a.m.	5	7	11.0 a.m.	0	1	,, 19
	5.30 p.m.	5	6	11.10 p.m.	0	3	
,, 20	5.38 a.m.	5	3½	11.40 a.m.	0	2	,, 20
	6.11 p.m.	5	5	12.5 a.m.	0	7½	,, 21
,, 21	6.20 a.m.	5	1	12.33 p.m.	0	6½	
	6.52 p.m.	5	2	12.30 a.m.	1	0	,, 22

All heights measured from Durban Harbour Datum Mark.

All times are expressed in South African Civil Time, or 2 hours fast on Greenwich M.T.

SCHEDULE V.

Data Measured on Cape Town Tide Gauge Record, June, 1905.

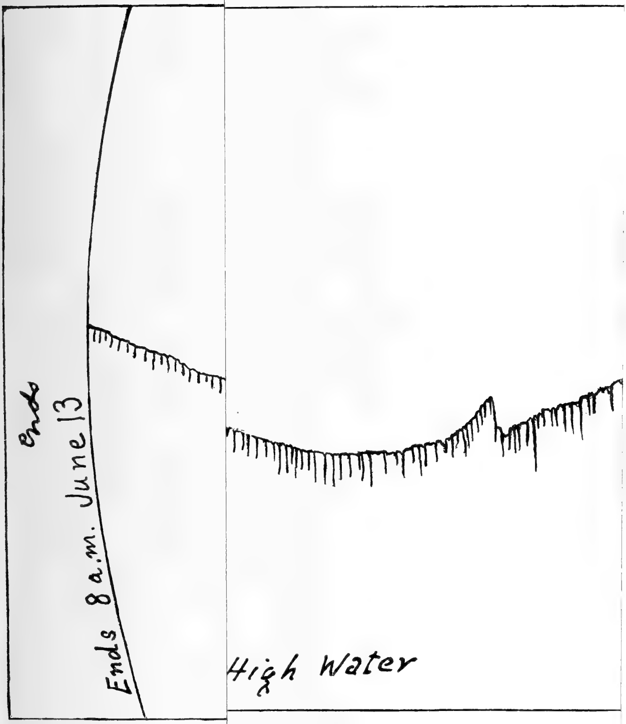
High Water.			Low Water.		
Date.	S.A. Time.	Height.	S.A. Time.	Height.	Date.
		Feet.		Feet	
June 4	4.55 a.m.	5·10	11.15 a.m.	1·03	June 4
	5.20 p.m.	4·95	11.30 p.m.	1·74	
,, 5	5.35 a.m.	5·20	11.40 a.m.	1·43	,, 5
	6.0 p.m.	5·00	12.20 a.m.	1·48	,, 6
,, 6	6.25 a.m.	4·78	12.45 p.m.	1·30	
	6.55 p.m.	4·65	1.15 a.m.	1·49	,, 7
,, 7	6.55 a.m.	4·42	12.55 p.m.	1·38	
	7.25 p.m.	4·53	2.20 a.m.	1·71	,, 8
,, 8	8.10 a.m.	4·29	2.30 p.m.	1·62	
	8.50 p.m.	4·61	3.10 a.m.	1·80	,, 9
,, 9	9.0 a.m.	4·15	3.30 p.m.	2·10	
	9.35 p.m.	4·50	4.15 a.m.	1·66	,, 10
,, 10	10.15 a.m.	4·00	4.40 p.m.	1·52	
	11.15 p.m.	4·46	5.35 a.m.	1·14	,, 11
,, 11	11.55 a.m.	3·93	5.50 p.m.	1·26	
,, 12	12.10 a.m.	4·32	6.35 a.m.	0·72	,, 12
	12.50 p.m.	4·10	6.45 p.m.	0·95	
,, 13	1.0 a.m.	4·56	7.50 a.m.	0·60	,, 13
	2.0 p.m.	4·39	7.40 p.m.	0·90	
,, 14	2.15 a.m.	4·92	8.15 a.m.	0·88	,, 14
	2.50 p.m.	5·00	9.5 p.m.	1·12	
,, 15	3.0 a.m.	5·36	9.30 a.m.	0·87	,, 15
	3.30 p.m.	5·26	10.0 p.m.	1·00	
,, 16	3.50 a.m.	5·18	9.50 a.m.	0·80	,, 16
	4.25 p.m.	5·19	10.25 p.m.	1·60	
,, 17	4.30 a.m.	5·40	10.45 a.m.	0·88	,, 17
	5.0 p.m.	5·09	11.15 p.m.	0·99	
,, 18	5.5 a.m.	4·64	11.25 a.m.	0·63	,, 18
	5.35 p.m.	4·58	11.20 p.m.	0·77	
,, 19	5.45 a.m.	4·24	11.40 a.m.	0·68	,, 19
	6.15 p.m.	4·25	12.5 a.m.	0·94	,, 20
,, 20	6.25 a.m.	4·00	12.20 p.m.	1·03	
	7.0 p.m.	4·38	1.45 a.m.	1·59	,, 21

Heights are measured from Table Bay Datum Mark.
Times are South African Civil Time (2 hours E. of Greenwich).

SCHEDULE VI.

Clock Rate Data for the Water-level Records of 1908, and Concurrent Barograms.

Week Record Sheet.		Lengths of Record in Inches.	Lengths of Record in Hours.	Deduced Rates in Inches per Hour.
Put on at—	Taken off at—			
6.40 a.m., March 2	7.20 a.m., March 9	12·1	168·6	·0717
7.20 a.m. ,, 9	8.0 a.m. ,, 16	12·2	168·6	·0724
8.0 a.m. ,, 16	9.5 a.m. ,, 23	12·1	169·1	·0715
9.6 a.m. ,, 23	6.50 a.m. ,, 30	12·0	165·7	·0724
6.50 a.m. ,, 30	8.0 a.m., April 6	12·15	169·2	·0718
8.5 a.m., April 6	8.30 a.m. ,, 13	12·1	168·4	·0718
10.30 a.m. ,, 13	10.0 a.m. ,, 20	12·1	167·5	·0722
10.0 a.m. ,, 20	9.40 a.m. ,, 27	12·05	167·6	·0719
9.45 a.m. ,, 27	10.35 a.m., May 4	12·15	168·8	·0719
10.35 a.m., May 4	8.20 a.m. ,, 12	12·16	189·7	·0717
8.20 a.m. ,, 12	9.15 a.m. ,, 18	10·5	144·9	·0724
9.15 a.m. ,, 18	9.30 a.m. ,, 25	12·15	168·3	·0722
9.35 a.m. ,, 25	9.25 a.m., June 1	11·95	167·8	·0712
9.25 a.m., June 1	1.10 p.m. ,, 8	12·4	171·7	·0722
1.10 p.m. ,, 8	9.50 a.m. ,, 15	11·95	164·7	·0725
Barograms.				
6.31 a.m., March 2	7.11 a.m., March 9	11·1	168·7	·0659
7.13 a.m. ,, 9	8.0 a.m. ,, 16	11·07	168·8	·0655
8.0 a.m. ,, 16	9.9 a.m. ,, 23	11·0	169·1	·0650
9.10 a.m. ,, 23	6.45 a.m. ,, 30	10·85	167·6	·0647
6.45 a.m. ,, 30	8.10 a.m., April 6	11·05	169·4	·0652
8.10 a.m., April 6	10.35 a.m. ,, 13	11·17	170·4	·0655
10.35 a.m. ,, 13	10.5 a.m. ,, 20	10·95	167·5	·0654
10.5 a.m. ,, 20	10.10 a.m. ,, 27	10·9	167·9	·0649
10.0 a.m. ,, 27	10.15 a.m., May 4	11·0	168·25	·0654
10.15 a.m., May 4	8.25 a.m. ,, 12	12·38	190·2	·0651
8.25 a.m. ,, 12	9.23 a.m. ,, 18	9·5	145·0	·0655
9.25 a.m. ,, 18	9.50 a.m. ,, 25	11·01	168·4	·0654
9.50 a.m. ,, 25	9.40 a.m., June 1	10·96	167·8	·0653
9.40 a.m., June 1	1.20 p.m. ,, 8	11·04	171·7	·0643
1.20 p.m. ,, 8	9.56 a.m. ,, 15	10·74	164·6	·0653


Ends
Ends 8 a.m. June 13
High Water

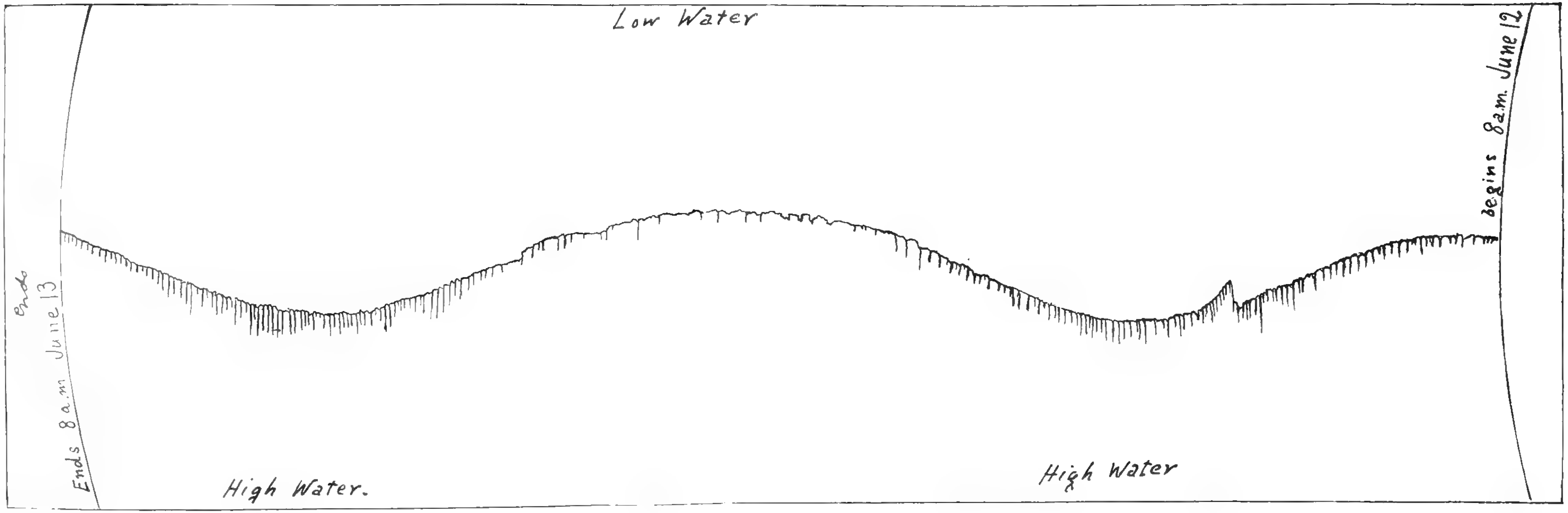
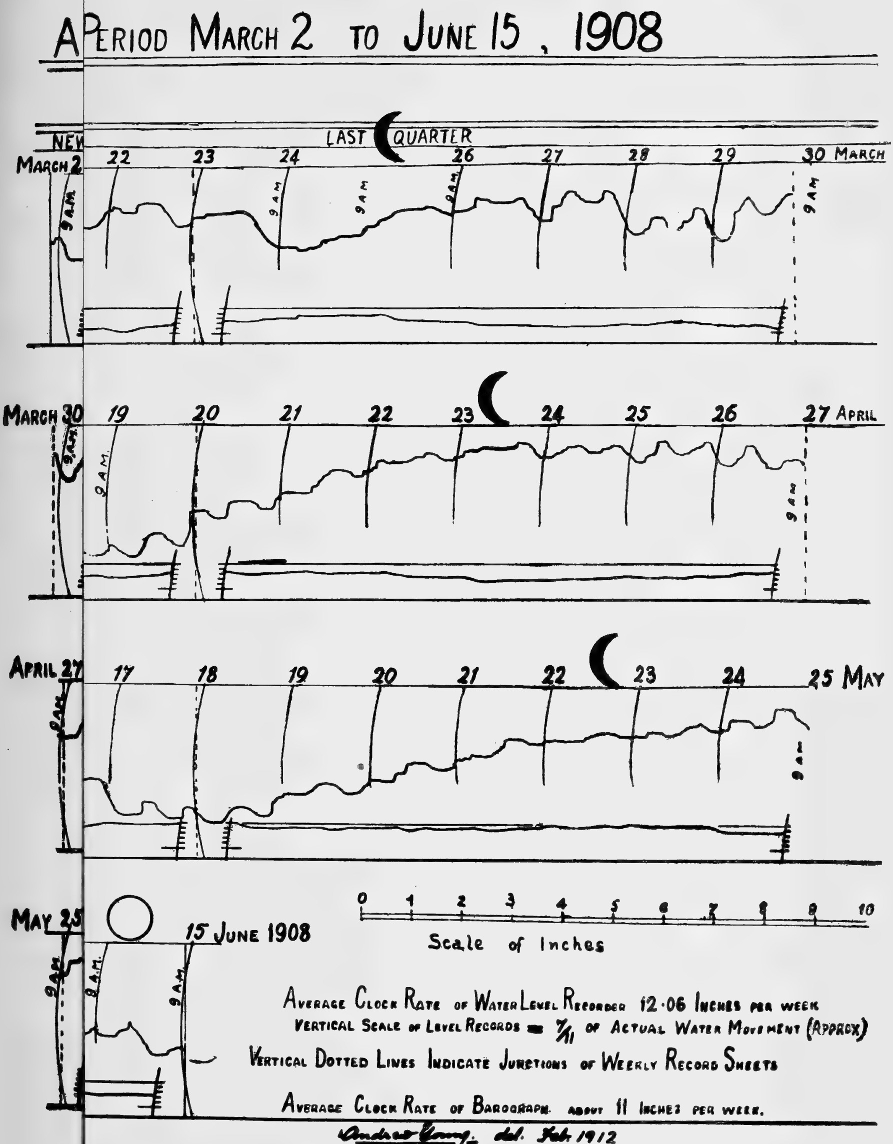

Low Water
begins 8 a.m. June 12
Ends 8 a.m. June 13
ends
High Water.
High Water

Fig. 4


A Period March 2 to June 15, 1908
NEW
Last Quarter
March 2
22
23
24
26
27
28
29
30 March
9 AM
March 30
19
20
21
22
23
24
25
26
27 April
April 27
17
18
19
20
21
22
23
24
25 May
May 25
15 June 1908
0 1 2 3 4 5 6 7 8 9 10
Scale of Inches
Average Clock Rate of Water Level Recorder 12·06 Inches per week
Vertical Scale of Level Records = 7/11 of Actual Water Movement (Approx)
Vertical Dotted Lines Indicate Junctions of Weekly Record Sheets
Average Clock Rate of Barograph about 11 Inches per week.
del. Feb. 1912

AUTOMATIC RECORDS OF WATER LEVEL IN BORE-HOLE No. V AND OF BAROMETRIC PRESSURE AT TARKA BRIDGE FOR THE PERIOD MARCH 2 TO JUNE 15, 1908

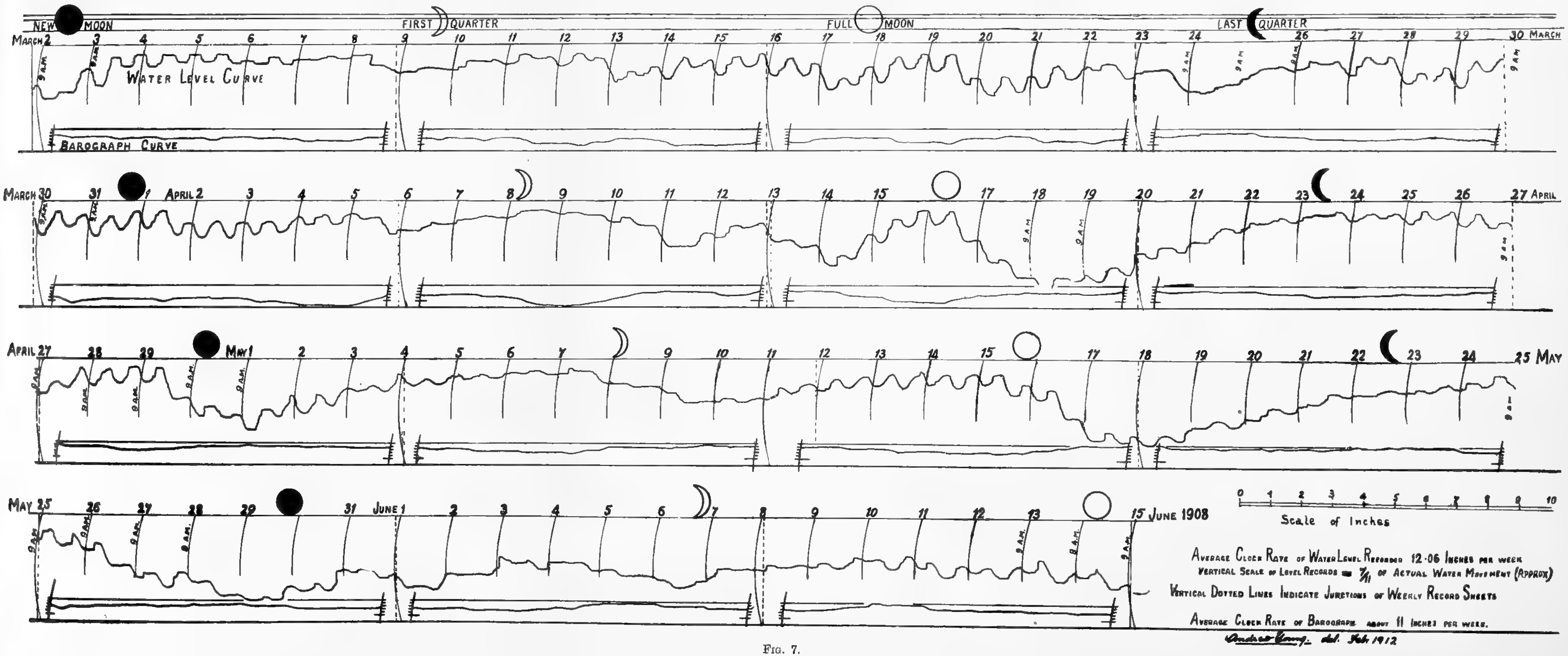
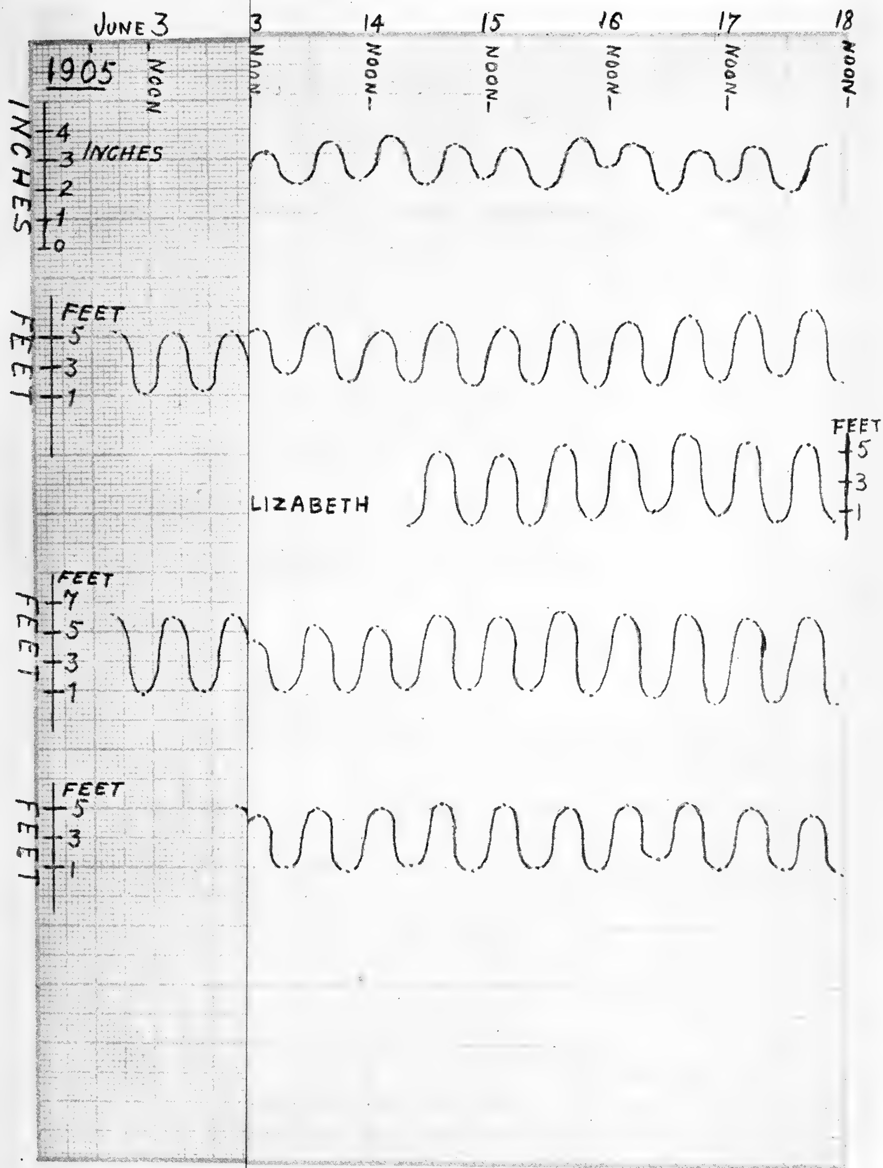


FIG. 7.


JUNE 3
3
14
15
16
17
18
1905
NOON
INCHES
4
3
2
1
0
FEET
5
3
1
LIZABETH
7

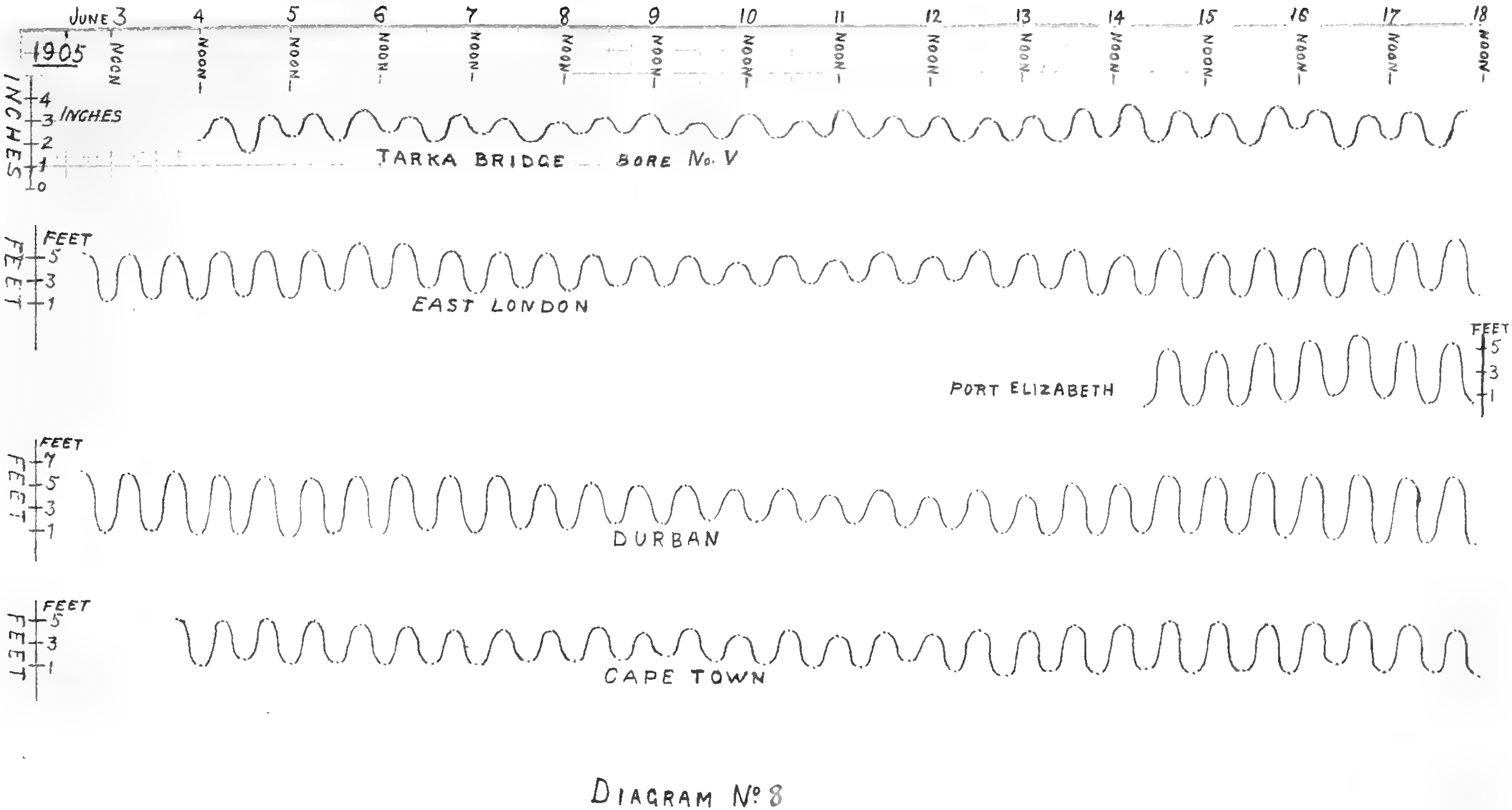
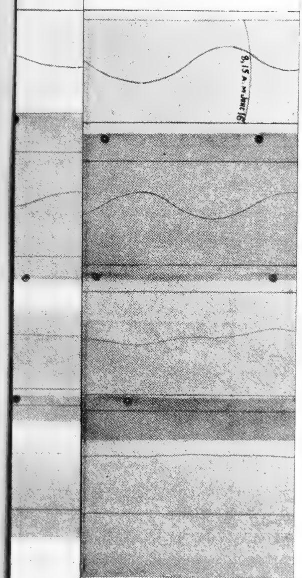

JUNE 3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
1905
NOON
INCHES
TARKA BRIDGE BORE No. V
FEET
EAST LONDON
PORT ELIZABETH
DURBAN
CAPE TOWN
DIAGRAM No 8

Fig. 8.


8.15 A.M. JUNE 16


ORIGINAL CURVE 'A'
LOW WATER
'D' = (A−C)
RESIDUAL CURVE 'H'
SCALE OF INCHES
SCALE OF CENTIMETRES
ENDS

Fig. 9.

APPENDIX.

As Chrystal's Residuation Method appears to be little known, and his original paper seems to be difficult of access in South Africa, I quote his description, which is as follows:—

"METHODS OF RESIDUATION.—In practice on Loch Earn, more particularly in our attempts to determine the positions of the nodes, we were compelled to work with short, large-scale limnograms; and the seiches were rarely pure. In these cases we resorted very often to a certain way of treating the limnogram, which we came ultimately to call 'Residuation.'

Consider a compound seiche, the equation of whose limnogram is—

$$y = A_1 \sin \frac{2\pi}{T_1}(t - a_1) + A_2 \sin \frac{2\pi}{T_2}(t - a_2) + \ldots \ \&c. \qquad (18)$$

Construct a new curve by slipping the curve (18) a distance τ backwards along the t-axis, and from these two curves form a new one by adding the ordinates; or, what comes to the same thing, derive from (18) a new curve by adding to the ordinate at each point the ordinate of the point whose abscissa is greater by τ.

The equation of the resulting curve is—

$$\eta = 2A_1 \cos \frac{\pi\tau}{T_1} \sin \frac{2\pi}{T_1}\left(t - a_1 + \frac{\tau}{2}\right) + 2A_2 \cos \frac{\pi\tau}{T_2} \sin \frac{2\pi}{T_2}\left(t - a_2 + \frac{\tau}{2}\right) + .$$

The derived curve, or residual with respect to τ, contains in general all the harmonic oscillations of the original. The phase of each component is retarded by the same time, $\frac{1}{2}\tau$; and the amplitudes are altered in different proportions, viz.—

$$2 \cos (\pi\tau/T_1) : 1, \ 2 \cos (\pi\tau/T_2) : 1, \ \&c.$$

Suppose, in particular, that we put $\tau = \frac{1}{2}T_1$; then the first component disappears altogether, and we get a curve, whose equation is—

$$\eta_1 = 2A_2 \cos \frac{\pi T_1}{2T_2} \sin \frac{2\pi}{T_2}\left(t - a_2 + \frac{T_1}{4}\right) + , \ \&c.$$

This last curve we call the residual of the limnogram with respect to the seiche of period T_1.

To show how this may be used in practice, suppose we have a short, large-scale limnogram, the principal or only components in which are the uninodal seiche (T_1) and the binodal (T_2). In general one, say the uninodal, will predominate; the other may be scarcely perceptible at first sight. Selecting two turning-points (points of symmetry, of course, if such are available), we divide the difference between the corresponding points by the number of intervening major oscillations. The result will be an approximation to T_1, say T'_1; but generally only an approximation, because the turning-points are displaced by the other seiches, mainly by the binodal.

Now residuate with respect to T'_1. The result will be a curve in which the uninodal harmonic is very much reduced, and will show the binodal in predominance. From this determine an approximation to T_2, say T'_2.

Now return to the original limnogram, and residuate with respect to T'_2. The result will be a curve from which the binodal harmonic is nearly absent. Hence the turning-points of the uninodal will be much less disturbed than before; and we can now get a better approximation to T_1, say T''_1.

Residuate now the original limnogram with respect to T''_1, and we get a curve in which the binodal is less disturbed than before. We can therefore make a closer approximation, say T''_2, to T_2; and so on.

The process can, if necessary, be repeated until the accumulated errors incidental to the manipulation obliterate the essential features of the diagram with which we are dealing.

In this way the periods of two or even three seiches can be determined, one after the other, from a comparatively short large-scale limnogram. We discovered in this way seiches the existence of which had not been suspected; and without this process we should not have obtained a determination of the period of the trinodal seiche of Earn at all, which never occurred pure, and had always a comparatively small range. The process was also used in purifying compound limnograms with a view to determine nodes" (Trans. Roy. Soc., Edinburgh, vol. xlv., part 2 (No. 14), p. 385).

DESCRIPTIONS OF SOME NEW BATRACHIA AND LACERTILIA FROM SOUTH AFRICA.

BY JOHN HEWITT, B.A., and PAUL A. METHUEN, F.Z.S.

(Read July 17, 1912.)

(With Plate VII.).

BATRACHIA.

NATALOBATRACHUS BONEBERGI, gen. et sp. nov.

Mr. Hewitt has recently received from the Rev. Father Boneberg, of Mariannhill, several specimens of a frog which represents a genus new to South Africa, and seems to have been undescribed. It belongs to the Family Ranidæ, and is generically related to *Phrynobatrachus*, *Staurois*, and *Oreobatrachus*: it is distinguishable from the two former by the possession of T-shaped terminal phalanges, and from *Oreobatrachus* in that the tongue is deeply incised behind and there is no continuous dermal fold between the choanæ. The frog may be described as follows :—

NATALOBATRACHUS, gen. nov.

Pupil horizontal. Tongue free and bifurcated behind. No vomerine teeth. Fingers free, their terminal phalanges T-shaped, and without any supernumerary phalanx between the two distal phalanges ; toes webbed ; outer metatarsals distinctly separated by web distally, but proximally united. Ziphisternum and omosternum each with a long and slender bony style.

NATALOBATRACHUS BONEBERGI, sp. nov.

Figs.

Snout triangular, somewhat pointed and projecting in front ; nostril nearer to tip of snout than to the eye. Tympanum distinct, a trifle more than half the size of the eye. No median papilla on the tongue. No indication of external vocal pouches in the male. Dorsal surfaces without folds, with a tendency to become roughened or granulated ; belly smooth ; thighs somewhat granulated behind. Fingers free, their tips dilated into triangular discs, which are not as big as the tympanum; the two inner fingers small, the first one shorter than the second, the third and fourth considerably bigger, the former being the longest. Toes about half-webbed or very slightly less, their tips distinctly dilated, but not so much as the fingers ; a small inner metatarsal tubercle ; a slight skin flap at the heel. Tibio-tarsal joint of adpressed hind-limb reaching to the nostril.

Upper surfaces brownish, sometimes with small rusty-red spots ; limbs with darker cross-bars, which are pale margined on the thighs ; ventral surfaces pale in the female, the throat, breast, and to a less extent the lower surfaces of the limbs fuscous in the male ; a pale whitish band with ill-defined border passes from the nostril below the eye and tympanum to the base of the fore-limb. Size : From snout to vent, 37 mm.

Locality : Mariannhill, Natal.

Father Boneberg found this species among the stones in the sandy shallows of a small rivulet which was concealed under a thick growth of creepers and thorns in the bushland near Mariannhill. In the same place he also found clusters of spawn, which was either attached to rock not covered by water, or to the slender branches overhanging the water at a height of several feet above its surface.

Description drawn up from four specimens ; types in the Albany Museum and Mariannhill Museum.

Bufo fenoulheti, nov. sp.

Crown without bony ridges ; head broader than long ; snout triangular and slightly protecting beyond the mouth, with fairly distinct canthus ; interorbital space flat ; eustachian tubes present ; tympanum distinct, about half the size of the eye, or slightly more. First finger only very slightly longer than the second or subequal thereto ; the subarticular tubercles of the fingers mostly double. Toes about $\frac{1}{3}$ webbed ; subarticular tubercles under fourth toe double, and there may be doubled tubercles under the fourth and fifth toes. The lower surface of the tarsus and foot is beset with a number of tubercles, the two metatarsal tubercles being scarcely or not at all larger than those on the tarsus ; no tarsal fold. The tarso-metatarsal articulation of the adpressed hind-limb reaches the posterior border of the eye. Upper surfaces of the body covered with numerous, closely set, small, rounded, and somewhat blister-like warts, each carrying one or many minute spines. Throat in female quite smooth, in the male very finely granular. Lower surfaces of body almost smooth, with a reticulated, but not granular, surface. Parotoid glands depressed and broad, kidney-shaped. Dorsal surfaces with darker brown patches more or less symmetrically arranged on a lighter brown or greyish ground colour; a dark bar between the eyes, anterior and posterior to which is a pale area; the dark patches on the body ill-defined. Female, from snout to vent, 38 mm.; male, from snout to vent, 33 mm.

Description drawn up from three specimens, which seem to be sexually mature. Localities: Newington, N.E. Transvaal (Dr. J. P. Fenoulhet), March, 1912, 1 ♂; the Woodbush (Miss A. Eastwood), December, 1911, 1 ♂ and 1 ♀.

Types: The Newington example in the Albany Museum (No. 1520) and the Woodbush examples in the Transvaal Museum (Nos. 508 and 509).

This toad seems to be distinct from *Bufo regularis* in the absence of granulations on the belly and in the double subarticular tubercles of the digits; from *vertebralis* it is distinguished through the better developed parotoids and the stronger development of asperities on the dorsal surface; *gariepensis* (*granti*) and *angusticeps* are easily distinguished by their distinct tarsal fold.

It is of interest to note that, according to Mr. Boulenger (P.Z.S., 1907, p. 479), the colour pattern of some examples of *Bufo regularis* from the Woodbush is very unusual, and "they might be well thought to indicate a distinct species were they not connected with the more typical form by every possible gradation." He also mentions some specimens from Beira, in which the parotoids are exceptionally so flat as to be hardly distinguishable. As Mr. Boulenger adds nothing with regard to the various other characters utilisable for specific distinction, we may perhaps infer that the Woodbush specimens were essentially the same as *regularis* in those respects. But if it shall eventually prove that the characters just described in *fenoulheti* grade completely into those of *regularis* it will be no longer possible to maintain the specific identity of *vertebralis*, as this new form is quite as near to *vertebralis* as to *regularis*.

LACERTILIA.

Tetradactylus eastwoodæ, n. sp.

Serpentiform; limbs very short. The anterior limb with three very small digits, each with a claw, the middle digit longest; posterior limb with two digits, both clawed, the inner one minute. Dorsal shields striated and strongly keeled in 12 longitudinal and 67 transverse rows; ventrals in 6 longitudinal series. The head shields similar to those of *T. africanus*, but the interparietal is more elongated, separating the frontoparietals and forming a suture with the frontal. Femoral pores 3.

Uniformly brown above, except for some small black spots on the head; pale ventrally.

Total length, 190 mm. (a portion of the tail has been reproduced); from snout to vent, 64 mm.; length of fore-limb 5 mm., of hind-limb 6·5 mm.

The type and only known specimen was taken in the Woodbush (Zoutpansberg District) by Miss A. Eastwood, who presented it to the Transvaal Museum in April, 1912.

This new species is closely related to *T. breyeri* Roux, but is easily distinguished therefrom by the limb characters.

Type in the Transvaal Museum (No. 1496).

Zonurus cœruleopunctatus, n. sp.

Head much depressed, much longer than broad, the head shields almost smooth; no supranasals; nasals of moderate size, not swollen, only just in contact in the mid-line; frontonasal broader than long; prefrontals forming a median suture; interparietal enclosed between two pairs of parietals, of which the posterior is the larger; temporals smooth and without spines; the fifth upper labial is suborbital and not much contracted below; lower eyelid opaque. Scales of the back small, strongly keeled and arranged in transverse rows, about 20 scales in each row, and about 40 distinct rows, not including a number of minute scales which occur immediately posterior to the parietals, the occipitals being absent. In the middle of the back the scales of the 2 median rows are larger than those more laterally situated. Ventral scales in transverse rows, 10 in each row, the 2 most laterally situated, on each side, keeled; from the vent to the region of the rudimentary collar about 34 rows of scales. Lateral scales keeled, smaller than the dorsals, separated from each other by granular intervals and merging gradually into the dorsals. An ill-developed collar indicated on each side of the neck. Caudal scales keeled above and below, a little spinose near the base of the tail laterally; at least 55 whorls of scales in the tail (tip lost). Femoral pores 15 in a single row on each side.

The pale-brown ground colour of the dorsal surface of the body almost obscured by a number of blackish stripes arranged more or less longitudinally, fairly distinct anteriorly but broken up and fusing behind; on the sides of the head and body a few scattered bright blue flecks; the throat region orange; head, tail, and upper surfaces of limbs almost blackish.

Total length, 150 mm.; length of head, 19 mm.; greatest breadth of head, 13 mm.; length of tail, 85 mm. (tip lost). Though immature, the specimen no doubt represents a very distinct species, which may at once be recognised by the small scales of the post-parietal region; in this respect it resembles *Pseudocordylus microlepidotus*. The sutures in the neighbourhood of the nostril are not sufficiently defined to enable us to say if this new form agrees with *Zonurus* rather than *Pseudocordylus* in the nasal character. However, its nearest relatives seem to be *Zonurus warreni* and *Z. capensis*.

The only known specimen was taken in March, 1912, by Mr. Methuen at Buffels Nek, between Knysna and Avontuur, about 10 miles from Knysna; it was living amongst the rocks on a mountain devoid of forest, within the area of Cape Flora vegetation.

In all probability the species will prove to be very limited in its range, as seems to be the case with *Z. capensis*, which has never been recorded since the time when it was taken on the Hottentot Holland mountain, over 60 years ago.

Type in the Transvaal Museum (No. 1920).

Fig. 1.

Fig. 3.

Fig. 2.

Fig. 4.

NATALOBATRACHUS BONEBERGI, gen. et sp. nov.

Fig. 1.—The animal viewed from dorsal aspect. × $\frac{2}{3}$.
Fig. 2.—The animal viewed from ventral aspect. × $\frac{2}{3}$.
Fig. 3.—The left hand from below. Nat. size.
Fig. 4.—The left foot from below. Nat. size.

NOTES ON NAMAQUALAND BUSHMEN.

By Miss L. Currlé.

(With Additional Notes by L. Péringuey, F.R.S.S.Af.)

(Read July 17, 1912.)

The following was told me by one of our most progressive farmers—a gentleman whose veracity is above suspicion, and whose early life afforded him ample facilities for obtaining a clear insight into the characteristics of these people :—

The Bushmen consist of wandering tribes, different branches using different languages; they habitually move about after game, on which they live by preference; and when game is not procurable they live on roots and such things as mice and beetles, lizards, eggs, and white ants, called "rijs miere" (rice ants) by the Dutch people. The nests of these ants (termites) are underground and the Bushwomen are specially clever at finding these nests; they discover them by throwing down a stick which gives a hollow sound just above such a nest (*1*). This stick is from 3 to 4 feet long. To the one end is fastened the horn of a male springbuck (antelope), which has been straightened by warming in the fire; in the middle of the stick is a round stone weighing from 5 to 6 lbs. with a hole through it (the *! Kwè*), giving weight to the stick and making it more effective. The upper end of the stick is a little thinner than the lower part, to allow the stone to rest securely midway. This is the only implement the women have except the upper part of a tortoise-shell, which they use as a drinking vessel. An empty ostrich egg, corked by a plug of grass, is utilised for a water-bottle; this shell is carried on their back in a skin when they go a long distance to hunt for white ants and roots—this being specially the women's contribution towards the menu.

The women's dress consists of a skin fastened round the waist. Sometimes they wear round the neck a string of ornaments made from the shell of an ostrich egg, and decorate their woolly hair by stretching out the curls 2 or 3 inches in length, and fastening to them with their own hair little bits of stone and bone shaped according to their own fancy. They shape these stones and bones by rubbing them on another stone. The women are very fond of painting their faces with a certain kind of stone which they find in certain localities—no doubt hematite; they powder this on a flat stone by means of a round pounder or pestle about 3 inches in diameter. Another paint—a most favourite one with the Bushmen—is derived from a species of mushroom which grows in the shade under trees and bushes in Fraserburg and Calvinia districts, and called by them "Ajous"; it contains a fine red powder which they mix with the fat of an animal. Preferably ostrich fat is used by them for painting on rocks with this ajous powder, as this special fat is said to cause the paint to become lasting and hard, imparting with age a dark brownish colour similar to enamel.

The men use only bows and arrows (*2*). The string of the bow is made out of the sinews of some animal; the favourite stick for the bow is of a certain thickness and is taken from the Karree-tree (*Rhus sp.*). They thin the ends of the stick with a flint stone which is used instead of a knife; these flints are also used when slaughtering an animal and cutting up the flesh. The bows are also used as musical instruments; the Bushmen sit on the ground with crossed legs, put the one end of the bow against the right shoulder, and the other between their feet, and then strike the end of the bow with their forefingers. Their musical faculty consists in imitating most cleverly the sounds made by running animals, as animals are foremost in their thoughts and nature; they imitate the galloping, trotting, and cantering of a horse so perfectly that one imagines he hears the animal. They imitate the sounds made by the feet of the hare when running, preferably to all other sounds. They go out for long distances hunting for game, carrying their store of water in the cleaned stomach of a springbuck. When they go out for this purpose they generally go in parties. If their hunt is successful, they send messengers back to the waiting families ordering them to proceed to the hunting-ground; the trek is an easy matter, for the Bushmen possess no domestic animals, and they build no permanent huts. They live and feed on the meat as long as it lasts. When they have plenty of food they sleep during the day and dance through the night.

The following incident will illustrate some of their cunning, wanton cruelty, and wastefulness. In the district of Calvinia some Bushmen watched a herd of springbuck numbering from 5,000 to 6,000, feeding on a plateau which rose gradually on one side and ended in a steep precipice on the other. They drove the springbuck towards the precipice and wounded the one nearest the edge. The poor animal jumped to inevitable death and the rest followed, being driven on by the Bushmen in wild exultation. Word was sent far and wide to all and a great feast and dance was held. The fall of the animals produced a deep depression in the ground and could still be seen years afterwards, together with great heaps of the bleached bones of the unfortunate springbuck.

The Bushman roasts or boils all flesh before eating, roasting a hare whole—skin and all—under the coals and hot ash. They eat all kinds of animals—the hyæna, jackal, leopard, all buck and wild beasts; they do not disdain the crawling worm.

They never build any proper huts, only making a slight shelter of grass and twigs. When staying any length of time at a place they prefer to be on the low-lying hills, right in amongst the stones, where they are invisible, but from whence they can obtain a good view of the game grazing in the plains. They sometimes sit for hours—even days—watching and making plans to waylay the quarry, which they do as the game moves past into the hills. Sometimes they divide, one party approaching the animals, the other going a circular way, driving them towards the first who, when sufficiently near, use their bows and arrows.

They are wonderfully cunning in their methods. Occasionally they will creep up to an antelope or a hare flat on their stomach; they will tie a bundle of grass or a bush on their head so as to be unnoticed by the antelope. If it is a big animal, like the gemsbuck, for instance, they shoot it with a long poisoned arrow, and when the wounded animal runs away they patiently track it, showing remarkable skill in the pursuit. They never lose the tracks (spoors) of an animal, knowing that it will drop sooner or later from the effects of the poison. When it is found dead they wait a little while for the carcass to get cold, by which time it is supposed that the poison has found its way back to the place where the animal was wounded. Then they cut out the flesh surrounding the wound, so as to remove all the poison, after which process they eat the remaining meat with safety.

The poison for the arrows is obtained from different substances; snake poison is used, also that taken from a most deadly large spider called "baviaan's spinekop" (*3*); they also use the milky juice taken from a species of Euphorbia called "Boomgift" in Dutch, and which grows in the Langebergen.

They do not use any medicinal plants for ailments; they practise witchcraft to remove illness. The old women are called to attend a patient, and are supposed to remove the owl or wild cat or some such evil thing which is causing the pain by snorting round the patient—especially round the seat of pain.

The Bushmen keep no stock, or domestic animals; they never cultivate anything; they are not a warlike race; they acknowledge no chief or leader, but wander about in groups. They have no marriage customs, but they do not indulge in polygamy, being constant to one wife. If they should tire of her they might do away with her and take another.

Even in dry seasons, when great privations are endured, they have never been known to practise cannibalism.

They have a weird custom concerning the aged amongst them. When the latter can no longer follow the clan, which is constantly moving after the game, the younger men make a small kraal of thorny bushes and put the aged into this, together with a supply of food. When this is consumed they die of starvation, as the party has moved away. The thorny shrubs are supposed to prevent wild animals from devouring them.

Bushmen are very revengeful; when once they have a grudge against any one they never forget it, but wait patiently for their revenge. They never surrender; when driven into a corner they fight to the death (*4*); they are loyal to a master when attached—loyal unto death. In some cases they will kill their own relatives if necessary. This they can do in the coolest way, as the following illustration will show. "Droog Klaas" was a lazy Bushman who would not work, and who lived by stealing the stock herded by his relations for white masters. These herds got into trouble about missing stock, so they formulated a plan for the thief's destruction, finally inviting him to a daga smoke (wild hemp), this weed having the property of rendering its smokers quite senseless. Droog Klaas was very strong, so they cautiously asked him to wrestle after a while to try his strength; then as he still retained his strength, they persuaded him to smoke more daga, and when fully drunk they caught him by the hands and feet and one of the party calmly cut his throat.

"Janetje," an old girl long in the employment of the narrator's father, was of a mild disposition, and always respectful towards even the younger children, always calling them "Bassie" and "Nonnie," but to illustrate the inborn revengefulness of the Bushman nature, this true account of her actions is given, as told by her own sons to the narrator: Bushmen once stole some stock which were herded by Janetje's husband, "Zwaart-Piet" by name, and their sons, "Platje" and "Klaas." A hunt was organised to kill the thieves. Zwaart-Piet had an old-fashioned muzzle-loader. He was rather reckless, and went near the hole in which the Bushmen had taken refuge. Unfortunately, his gun would not go off, so while bending down to examine the cause of his failure, he was shot with a poisoned arrow and dropped dead. Years later a young Bushman came to Janetje's kraal, saying that he had been captured by a white man, had escaped, and was going to tell his people where the white man's cattle was grazing, so that they could come and steal them. By dint of questioning Janetje found out that he was the nephew of the man who shot her husband. Cautioning her people to let her alone and do as she pleased, she picked up a knobkerrie (club), and, passing close to where the young stranger sat chatting near the fire, suddenly she hit him on the one ear with such force that the blood shot out of the other ear. She then battered his head so that the brains came out, adding, "Throw him to the aasvogels (vultures) so that they can eat him. I am satisfied. I have had revenge of my husband."

Bushmen children have no set games. They imitate their elders in the use of the bow and arrow, shooting birds, mice, and lizards, which they roast and eat. They hunt for lizard eggs, which they find in holes in the ground, and gobble the contents. They imitate the sounds made by animals, but never play any game like other children. They will also try to straighten the reeds (which they use for arrows) by means of a stone implement heated in the fire (*5*). This stone is long and flat in shape, and has a central groove running through the whole length, into which the reed is pressed with stones, thus straightening the reed in an effectual way.

The Bushmen believe that they will rise again after death, and for this reason they bury their dead in a sitting position, so as to enable them to get up easily and walk to a certain mountainous place near the lower part of the Orange River, called by them "Koegas," where there is supposed to be plenty of wild honey and locusts. Those who have been quarrelsome and have behaved badly in their lifetime towards their friends will have common flies (house flies) to eat as a punishment for their bad behaviour; the good and favoured ones have wild honey and locust porridge to eat—doubtless two highly appreciated delicacies.

Bushmen are very superstitious. In the evening they never talk about any dangerous wild animals such as lions and leopards, because doing so would be taken for a bad omen, and these animals would come and eat them during the night.

The Bushmen believe that the vermin—jackals, wild cats, and like animals, even lions—were formerly some kind of human beings, and were transformed by witchcraft into wild animals ; this was their punishment for some bad act done by them once upon a time. These beliefs have been handed down for generations—perhaps centuries—from father to son. They believe that there was in the early days an evil person or devil who always quarrelled with the others, and was always trying to pick a quarrel for the slightest reason. One day this evil person or devil went out into the veld. He met a wild cat who was quietly walking about by himself hunting for game, and who, whilst so doing, had a habit of calling a certain name, "No'can no'chabd." * As soon as the devil heard him call that name, he said, "Oh, that is why my brother is so sickly, because you are always using this name in vain. How dare you do that ?"

* The name is, of course, reproduced here phonetically.

The cat took no notice of this, going on using the same name, so the devil got into a passion, walked up to the cat, and aimed a heavy blow at him. The cat very dexterously avoided it by quickly burying its head under the sand, and so the devil struck only the sand.

The cat then jumped out quickly and dealt him a heavy blow before he was ready. The devil recovered and aimed another heavy blow at the cat, but, as before, this was avoided by the cat again burying his head in the sand, and, as before, he jumped out quickly and dealt the devil another blow. This was repeated several times until at last the devil had to run away. When he stopped to fight, the devil put down his quiver with arrows and also his bow, which he had no time to pick up when he ran away, but he possessed the power of calling these things to follow him.

When the devil went out another time he found the meercats following the spoor of a wounded eland which had been wounded by one of the meercats with a poisoned arrow; the devil said in a very contemptuous way, "What funny people they are, such insignificant-looking people, so small in stature!"

He spoke thus in order to provoke their anger, and to pick a quarrel with them, but the meercats took no notice of all this. They quietly followed the eland's spoor. As the devil could not make them angry, he went and pushed the leader off the spoor and followed the spoor himself, but the meercat came and pushed him off very violently, and said, "Gar-'argi'-innim", meaning, "I am a big man, I carry a beard." but the devil pushed him off again. This was done repeatedly until at last they came to blows. The meercat, being a very clever fighter, soon gained the upper hand; in a short time there was nothing left for the devil but flight. The meercats then followed up the spoor of the eland peacefully, and captured their game without any further disturbance from the devil." These stories go to show that the Bushmen believe in an evil spirit.

In the above I have endeavoured to portray the nature, superstitions, and customs of the Bushmen living in Little Bushmanland, being now a portion of the Fraserburg, Calvinia, Carnarvon, and Kenhardt districts of the Province of the Cape of Good Hope.

ADDITIONAL NOTES.

By L. Péringuey.

(1) *The Digging Stick.*

I had lately at the Museum five colonial Bush people—two old men, one old woman, and two youths—from the Carnarvon and Prieska districts, and as purely bred as any to be found at present. After we had gained their confidence they answered readily diverse questions, the veracity of their answers being tested by repetition of the query at different times, and careful cross-questioning; for it was but too apparent that they were anxious to please. I suggested that they should make me a !*Kwè ka* !!*Kha*, or digging stick. They demurred; they had no stick, no stone, no springbok horn to make one with. But on their being shown a photograph of one such implement found in their own home, and one of their household chattels, and being further provided with what they said they had not, they made one, in the manner mentioned by Miss Currlé. The stick was the walking-stick used by one of the men, but the stone was fixed a little below the middle, not by the thickness of the wood, but by a wooden wedge inserted under the stone, at a part where after trial it was found that the stick was well balanced. The horn-shod point is used slantingly and not vertically in digging. The two men and the women had never heard of the stone and stick being used for detecting the presence of white ants under the ground, but only for opening the ant-hills, and digging out roots and bulbs. As for the !*Kwè* or perforated stones they were occasionally picked by them in the veld. No one with whom they were acquainted, meaning the Bush people, knew how to make these stones. They had been made by people who lived long before their own forbears. They were quite positive of that.

The two youths knew nothing about these !*Kwès*, or their use.

(2) *Bows and Arrows.*

Bows and arrows were of two sizes. The longer bow stands some five feet in length, and its use requires not only great dexterity but also extreme strength. I have it from a farmer in the Carnarvon District that in bending his bow at the fullest "the shoulder-blades of a Bushman could be seen coming together." This is, of course, a metaphoric way of explaining the great strain on the muscles of the arms and back of the Archer.

(3) *Venom of Spider.*

The "babiaans spinekops" are extremely large ground spiders very common in South Africa; but their bite is not "most deadly," in spite of the belief of the country people, although it is extremely painful. The base of the colonial Bush poison is snake venom with the adjunction of the "boomgift," *Amaryllis toxicaria*, or other plants. In the Kalahari the Bush races profess to use the grub of a beetle for the concoction of this poison.

(4) *They never Surrender.*

I am indebted to Mr. W. A. Russell for the following: Mr. ——, Calvinia District, told me that one of his earliest recollections was seeing his father go out with two other Boers to shoot an old Bushman, Piet Jachtpan. The Bushman had entrenched himself in a hole he had dug. The middle Boer advanced, holding a large shield of double oxhide. Under cover of this the other two, one at each side, advanced with their rifles. The Bushman, lying on his back, shot his arrows, using both feet and hands to stretch his bow. Some of his arrows travelled nearly a hundred yards. When they shot him they found he had cut through the skin of his finger-tips with the constant pulling of his bow-string. This Bushman had hit Mr. ——'s uncle with one of his poisoned arrows, but it had struck his head through the hair (or hat) and he recovered.

(5) *Heated Stones for straightening Arrow Shafts.*

Small, oftener flat, but sometimes also partly rounded stones with a longitudinal, but always shallow, and very seldom even, groove are considered to have been used for straightening the curve of the reeds used by the Bush people as shafts for their arrows, in the manner mentioned by Miss Currlé. I have already expressed elsewhere great doubts about this alleged process, because of the great unevenness of width, depth, or straightness of the groove, and I gave my reasons for considering them as whetting-stones for bone bodkins, or the reduction into cylindrical shape of the bone shafts tipping the reed-shaft of the arrow. I tested, however, my Bush people in the following manner: A small stone with a very uneven groove was first shown them. Yes, it was intended for straightening the reed; and the simulacre of daintily pressing half an inch of the reed at a time followed. When, however, I pointed out that the groove was neither straight nor deep enough, the old woman interposed by saying contemptuously that the stone I showed them was only a child's toy. Then another implement with a larger, regular, and deeper groove was produced, and evolved great satisfaction. The same explanation followed, but when it was pointed out to them that the texture of the stone, a piece of schist, could not stand the heat of any fire, the only explanation one of the two men could give was that it had first to be scrubbed carefully and then rubbed with springbuk blood, after which process it would stand any fire.

They admitted afterwards that warming before a fire would also permit of the straightening of the reed, just as it had of the lyrate shape of the springbuk horn, and also that they had not straightened arrows themselves, nor had they made any bone. On the other hand, this belief or simulacre of straightening arrow reeds in this manner may be a survival of the custom, with perhaps a symbolic meaning, of times when wooden shafts were straightened in the manner alleged.

SOME NEW OR LITTLE KNOWN SOUTH AFRICAN SUCCULENTS. Part V.

By R. Marloth, Ph.D., M.A., F.R.S.S.Af.

(Read August 21, 1912.)

(Plate VIII.)

Among the plants dealt with in the present paper are a few of special interest.

Crassula teres belongs to the small subgenus *Pyramidella,* of which *C. pyramidalis* is known to most visitors of the karoo. Like this and the allied *C. columnaris,* it possesses a fringe of hairs on its leaves which are capable of absorbing dew or rain-water.

Of the new species of Euphorbia one deserves special mention, viz., *E. ferox.* This forms rounded lumps about a foot in diameter, coloured brown like the soil of the karoo and provided with a formidable armament of stout spines. The colonial name "voetangel" is very appropriate, for if a barefooted person should happen to step on such a plant he would certainly not run any further.

Another interesting plant mentioned is *Aloe purpurascens.* This species, so far known only from cultivated plants, is considered by several authors to be merely a variety of *Aloe succotrina,* an error which is due to the want of information we possess about these plants. Up to a few years ago the habitat of neither species was known, and it was even thought that *A. succotrina* came from the island of Socotra and supplied the drug of that island. In fact, in one of the most modern handbooks, viz., Strasburger's, the species is still figured as the source of the drug. When a few years ago *A. succotrina* was found by us on a field of boulders at the foot of the eastern cliffs of Table Mountain, about 1,000 feet above Newlands, the locality of *A. purpurascens* remained still unknown. However, plants gathered near the mouth of the Klein River have now flowered in my garden and show very distinct differences in flowers and leaves from *A. succotrina* ; hence the uncertainty about the origin and specific difference of these two species is now removed.

CRASSULACEÆ.

Crassula teres, spec. nov. (Sect. *Pyramidella.*)
(Plate VIII., fig. 4.)

Caules e radice perenne plures, ascendentes vel suberecti, foliis dense obtecti. Folia carnosa, quadrifariam imbricata, transverse elliptica, superne concava, ciliata, margine hyalino amplo. Flores terminales, capitati, numerosi, albi, petalis linearibus recurvatis.

The plant is somewhat similar in shape to *C. pyramidalis*, but with leaves more like those of *C. columnaris.*

The adult stems are 5–8 cm. long and 15–20 mm. in diam., almost cylindrical, the four sides slightly flatter. Leaves basin-shaped, transversely elliptic, fleshy, with a broad hyaline margin and finely ciliate all round. Capitulum 25–30 flowered; flowers nearly white, sweet scented; sepals linear, with a broad hyaline margin, 3 mm. long. Corolla tubular and slightly inflated below, the inflated portion 3 mm. long, the free part of the petals linear, channelled for its entire length, not mucronate, much recurved, 10 mm. long; squamæ cuneate, 1 mm. long, deep yellow.

Collected in a sterile state on the Sand River Mountains near Prince Albert (quartzite) in 1907; flowering in my garden at Capetown in May, 1912. Marloth 4446.

EUPHORBIACEÆ.

Euphorbia ferox, spec. nov. (Sect. *Anthacantha.*)
(Plate VIII., fig. 1.)

Planta humilis e basi ramosa, ramulis pulvino hemisphærico aggregatis; caules ramique cylindrici; rami juniores 9–10-costati, adulti 10–12-costati, obtuse sulcati; costæ spinis acutis rigidis numerosis uniseriatim munitæ. Dioica. Cyathia feminea in apice ramorum sessilia vel brevissime pedunculata, longe campanulata, basi foliolis ovatis 5–8 suffulta; involucri segmenta parva, anguste cuneata, truncata, apice lacerata; glandulæ transverse ovales, suberectæ, virides. Styli haud connati, divergentes, stigmatibus bilobis.

The plants are much branched from a central subterranean stem, forming a compact cushion, 9–20 inches in diam.; bristling with long and stout, nearly straight spines. Stems 30 mm. in diam., 10–12 ribbed, the younger branches 9–10 ribbed; ribs 6–8 mm. broad and 4–5 mm. high, the crest smooth near the apex, but lower down raised into blunt teeth between the spines. Spines uniseriate, stout, sharp-pointed, on older shoots 20–30 mm. long, those near the apex straight, the others curving slightly upwards, close together, often only 3–4 mm. distant from each other. Plants dioecious. The female cyathia on short pedicels, 1 mm. long, bracts 6–8, the lowest very small, the three upper broadly oval, blunt and lacerated at the apex, ciliate. Involucre tubular campanulate, 3 mm. long, at the mouth 2 mm. in diam.; segments not touching each other, ovate-cuneate, truncate, finely lacerate at the apex; glands suberect, transversely oblong, green, rugose, the margin wavy, but entire. Ovary ovate, acute, the styles joined for 1 mm., the branches 2 mm., spreading, the stigmas red, bilobed.

In its general habit this plant somewhat resembles *E. pulvinata*, Marl. (Trans. Roy. Soc. S.A., vol. i., 315), but the branches are longer, the spines more numerous and much stouter, and the flowers quite different.

Gathered at Klipplaat (Eastern Karoo), and cultivated in my garden at Capetown for many years, flowering the first time August, 1912. Marloth, No. 5147. Colonial name, "voetangel."

Euphorbia filiflora, spec. nov. (Sect. *Medusea.*)

(Plate VIII., fig. 3.)

Planta humilis, caule clavato, apicem versus ramis nonnullis erectis, crassis, brevibus, foliis linearibus; pedunculis elongatis filiformibus. Cyathia cylindracea, segmentis obovato-obtusis, ciliatis; glandulæ horizontales, oblongæ, centro depressæ, virides, dentibus 4–5 linearibus, albis, apice recurvatis; ovarium triangulare, stylo longo, stigmatibus brevibus, simplicibus.

The plant resembles in its general habit *E. multiceps* from the karoo and *E. namibensis* from Great Namaqualand, but differs conspicuously by its long filiform pedicels. Stem 20–30 cm. high, 8–10 cm. in diam., the branches 5–8 cm. long and 8–10 mm. in diam., the podaria conically elongate, their apex curving slightly downwards; leaves linear deciduous, 20–30 mm. long. Peduncles 6–9 cm. long, filiform, bearing 2 or 3 distant bracts; cyathium 12–14 mm. long and half as wide; glands $1\frac{1}{2}$ mm. long and 2 mm. broad, the teeth 2 mm. long. Ovary shortly stipitate, styles 5 mm. long, for $\frac{2}{3}$ of their length connate.

The latex of this species is employed by the colonists for removing warts from man or beast. Marloth, No. 5119, sterile, at Chamis in Great Namaqualand, October, 1910. Also sent from Concordia in Little Namaqualand by Mr. J. C. H. Krapohl, March, 1912. Flowering in my garden at Capetown in November.

Euphorbia tuberculata, Jacq.

(Plate VIII., fig. 2.)

There are no specimens of this plant in European herbaria, the species being known only from Jacquin's figure and description (Hort. Schoenbr.

ii., 43, T. 208). The plant is, however, fairly frequent in the sandy tracts of the coast districts from Darling to Clanwilliam.

Young plants, when not in flower, somewhat resemble *E. caput medusæ*, the central stem generally remaining buried in the ground. While, however, in *E. caput medusæ* the broad apex of the stem continues to produce short branches on its sides, thus gradually forming a cushion-shaped body, the stem of *E. tuberculata* ceases to grow, the branches on the other hand becoming thicker and considerably elongated, thus forming a group of cylindrical stout stems 1–2 feet high.

When flowering these groups are very ornamental, for each shoot carries a dense head of 30–50 large flowers, which are borne on long stalks, the glands being green and their teeth white.

In cultivated plants, as that from which Jacquin's figure was drawn, these erect branches may occasionally branch again.

Euphorbia Dregeana, E. Mey.

The description of this species in DC.'s prodromus (vol. xv., sect. 1, p. 95) was made from incomplete specimens only. As I have cultivated the plant for some years in my garden I am enabled to add the characters of the leaves.

Leaves on young shoots only, alternate, sessile, triangularly cordate, acuminate, concave and channelled above and much recurved ; length 6–8 mm., width 3–4 mm. at base, deciduous.

This plant is probably the same as *E. elastica*, Marl., No. 4684 (Trans. Roy. Soc. S.A., vol. ii., p. 37), hence we prefer to cancel the latter name and refer it to the synonyms.

ASCLEPIADACEÆ.

Stapelia albo-castanea, spec. nov.

(Plate, VIII., fig. 5.)

Planta humilis, ramosa ; inflorescentia ramificata, 3–6-flora, floribus longe pedicellatis. Corolla radiata, tubo brevissimo, paullo concavo ; segmenta elongato-triangularia, albida vel flavescentia, transverse brunneo-maculata, pilis clavatis ciliata. Coronæ exterioris segmenta linearia, apice bipartita, castanea ; coronæ interioris segmenta subulato-filiformia, erecto-conniventia apice recurvata, dorso longe cornuta.

Stems 6–8 cm. long, curving upwards, glabrous, nearly quadratic, the sides, without the teeth, 12–14 mm. broad, the teeth 3–5 mm. long, the surface glabrous, dull green, mottled with dull red spots. Flowers several, 3–6, from the middle portion of a stem, opening in succession, the peduncles joined at base and forming a common stalk, 4–6 cm. long, curving upwards. Inner surface of corolla coarsely rugose, nearly white, spotted all over with purple brown, the spots around the corona smaller than the rest.

Sepals ovate and acuminate; the corolla 25 mm. in diam., with a very shallow cup, which slightly exceeds the sepals, the tubular portion 8 mm. in diam., the segments 10–11 mm. long and 5 mm. wide at their base, subacute, finally recurved.

Outer corona lobes linear, 2 mm. long and $1\frac{1}{2}$ mm. broad, recurved spreading, appressed to the corolla, not tapering, convexly curved on the upper side, the apex deeply notched, entirely dark brown; inner corona lobes 4–5 mm. high, about 4 times as long as the anthers, subulate filiform, acute, connivent erect and more or less spreading at the tips, with a long dorsal acute horn from its base, entirely brown, or whitish at the tips.

The plant would come near *St. jucunda*, N. E. Br. (Flor. Cap., vol. v., 1, p. 975), but in that species the petals are shorter in proportion and the inner corona lobes are merely gibbous at base, not horned.

Gathered near Maltahoehe in Great Namaqualand; flowering in my garden at Capetown in February, 1912. Marloth, No. 5110.

On one of my plants, among a collection of eight, the ground colour of the corolla was not pure white, but creamy.

Stapelia cincta, spec. nov.

Planta humilior, e radice ramosa. Caules brevissimi, ovato-acuminati, 4-angulares, angulis obtusis, denticulatis. Flores basales, solitarii, pedunculati, radiati. Corollæ tubus hemisphæricus; segmenta ovato-acuminata, tubo paullo longiora, non ciliata, ochracea, rugosa, dense brunneo-maculata, margine brunneo cincta. Coronæ exterioris segmenta lanceolato-acuminata, brunnea; coronæ interioris segmenta linearia, erecta, apice obtuso paullo recurvata.

A small plant, of the size of *Duvalia reclinata*. The stems nearly quadratic, 30–40 mm. high and 16–20 mm. in diam.; the sides almost flat, the teeth of the margin $\frac{1}{2}$ mm. long. Calyx glabrous, the segments broadly ovate, suddenly contracted into a point, their length about $\frac{1}{3}$ of that of the corolla tube. Diam. of flower 24–26 mm., the segments 10 mm. long and 5–6 mm. broad at their base, mottled, margined with a dark maroon band, 1·5–2 mm. broad. Outer corona lobes 2 mm., narrow lanceolate, the inner lobes very narrow below, filiform above, slightly longer than the outer lobes, slightly recurved, knobbed; both coronas dark maroon.

In the key of the Flora Capensis this species would have to be grouped with *St. stricta*, Sims (No. 25, p. 927), differing from it by its smaller size, the spotted corolla, the brown margin, the acuminate lobes of the outer corona and the longer inner corona lobes.

Plants brought from the Nieuwveld Mountains near Beaufort West; flowering in my garden at Capetown, March, 1912. Marloth, 5116.

LILIACEÆ.

Aloe purpurascens, Haw.

This species is somewhat allied to *A. succotrina*, Lam., the habitat of both species being unknown until quite recently. In fact some authors state that the home of *A. succotrina* was the island of Socotra and that the drug aloes was manufactured from it. Both statements are wrong, for Cape aloes is prepared from *A. ferox*, and the home of *A. succotrina* is the Cape peninsula, where it occurs on a field of boulders about 1,000 feet above Newlands, on the rocks of the Little Lion's Head, near Hout Bay and in the scrub of the hills above Fishhoek Bay. (See Marloth, in Trans. S.A. Phil. Soc., vol. xvi., p. 213.)

When the latter species was rediscovered in 1905, after being lost for nearly two centuries, while the locality of the former remained still unknown, the question of the identity of the two species was raised again, for various authors look upon them merely as varieties or even as quite identical (see Flor. Cap. vi.,322), while others, *e.g.* Berger,* maintain their validity as distinct species.

We are now in a position to settle both questions, for *A. purpurascens* occurs on the coast of Hermanus, on rocks near the Klein River mouth, and it is certainly quite distinct from *A. succotrina.* There is a great similarity in the foliage, although the leaves of *A. purpurascens* are larger and broader at the base than those of *A. succotrina* and more glaucous. The flowers, however, are quite different. While those of *A. succotrina* are cylindrical with a narrow mouth, owing to the connivent points of the perianth segments, those of *A. purpurascens* have a widened mouth, owing to the recurving of the apices of the segments; thus in the latter species the mouth is wider than the tube, while in the former the base is the widest part. It is also interesting to find that there is some chemical difference as well, for while the flowers of *A. purpurascens* stain a solution of formaldehyde in which they are preserved, purplish, those of *A. succotrina* impart only a pink colour to the liquid. The leaves of both species turn dark red on drying.

Unfortunately some of the illustrations and statements published in various works are incorrect or based on hybridised plants. Berger states in a private letter to us that the figures in "Das Pflanzenreich" are only

* Engler, Das Pflanzenreich, iv. 38, iii. 2, p. 284.

approximate, and his description of the appearance of the leaves is just the reverse of that given in the Flora Capensis, where the leaves of *A. purpurascens* are called glaucous. Our observations on wild and cultivated plants agree with the latter statement, for the leaves of *A. succotrina* are more greenish than those of *A. purpurascens*, although we have both plants growing side by side.

The illustrations which come nearest to the appearance of the wild plants are *A. succotrina*, as represented in DeCandolle, Plantes grasses, tab. 85, and for *A. purpurascens*, as shown in Curtis Bot. Mag., tab. 1474, while both figures of Salm Dyck (vol. iv., sect. xxii., figs. 1 and 2) represent intermediate forms.

The colour in the figures cited has changed, for these books were published about one hundred years ago. The flowers of *A. succotrina* are a deep red, with small green tips, while those of *A. purpurascens* are somewhat paler, and the green part of the inner as well as outer segments is at least three times as large as in the other species.

Collected on rocks near Klein River mouth. Marloth, 5149.

Aloe Thraskii, Baker (Flora Cap., vi., 328).

The original description of this species was made from a plant cultivated in England (introduced by Cooper, 1860). As usual with our succulents, such plants are weaker, more elongated, and their inflorescence poorer than of those growing under natural conditions. *A. Thraskii* occurs on the coast of Natal—*e.g.*, at Umkomas—as a stout tree, 6–10 feet high, with leaves nearly twice as large as stated in the description, viz., 3½–4 feet long—in fact, they are the largest in the genus, even exceeding those of vigorous specimens of *A. Bainesii*. The inflorescence is not simple, as stated in the original description, but much branched, bearing from 5–10 erect stout spikes of reddish-yellow flowers, and there are generally two, or even three, such inflorescences on each plant.

A showy and very ornamental plant, flowering in my garden at Capetown in June.

DIOSCORACEÆ.

Testudinaria multiflora, spec. nov.

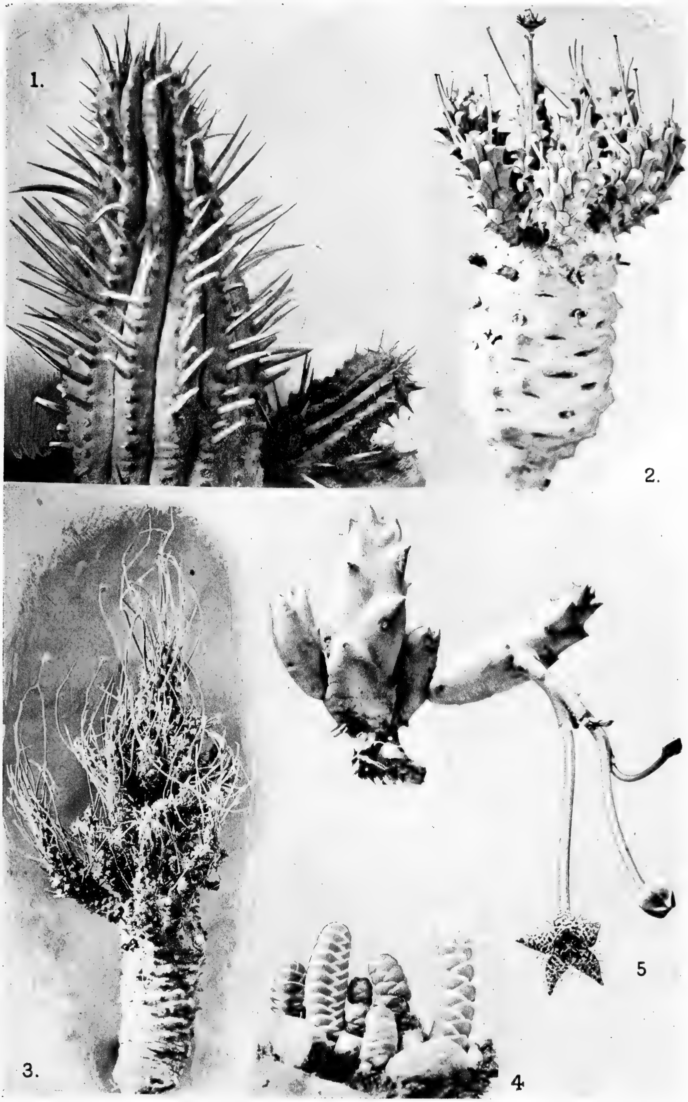
Tuber epigæum, valde depressum, haud areolatum. Caules scandentes, foliis cordatis, basi profunde lobatis, apice obtusis mucronatisque. Racemi feminei multiflori (20–40); capsulæ apice cordatæ, seminibus apice longe alatis.

The tuber somewhat resembles that of *T. silvatica*, but the leaves are much larger and deeply cordate at base, the two basal lobes occupying a third of the length of the leaf, and their inner edges are more or less closely approaching each other. Five of the nine principal nerves are running up to the apex of the leaf, the others terminate at the margin lower down. The capsules are very numerous, slightly cordate at the apex; the seeds possess a long apical wing, and sometimes a narrow hyaline margin at the base.

The plant differs in the shape of its leaves from the recently described *T. paniculata*, R. Dümmer (see Kew Bull., 1912, 195).

Tuber up to 12 inches in diam. and 3–4 inches thick; leaves 7–8 cm. long and 6–7 cm. wide near their base; raceme up to 5 inches long. The male plant not known.

Gathered in a fruiting condition by Mr. E. Dyke near Santa, in the Zoutpansberg Range (Transvaal), April, 1912. Marloth, 5097.



Photos by R. Marloth. West, Newman proc.

NEW SOUTH AFRICAN SUCCULENTS.

1. Euphorbia ferox *Marl.* (branch). 2. E. tuberculata *Jacq.* (young plant). 3. E. filiflora *Marl.* 4. Crassula teres *Marl.* 5. Stapelia albo-castanea *Marl.*
Nos. 1 and 5 are $\frac{2}{3}$, the others $\frac{1}{2}$ nat. size.

THE BLIZZARD OF JUNE 9–12, 1902.

By A. G. Howard, M.S.A., Cape Town.

(Read August 21, 1912.)

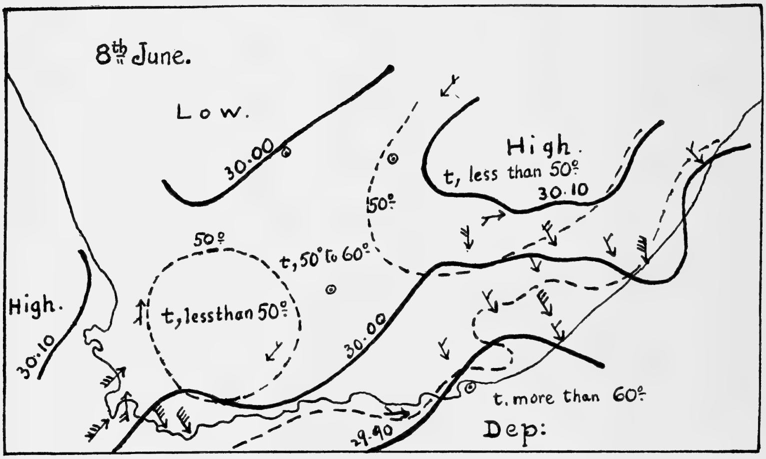
In November, 1904, a paper was read at Johannesburg before the South African Association for the Advancement of Science, the author of which was Mr. C. M. Stewart, B.Sc., at that time Secretary to the Meteorological Commission. The subject of this paper was "The Blizzard of June 9–12, 1902." It is therein surmised that "judging from the barometric readings, this storm seems to have originated in an area of low pressure in the north of the Colony, while the pressure in the west and south was increasing rapidly, after the passage of a depression south of our coasts."

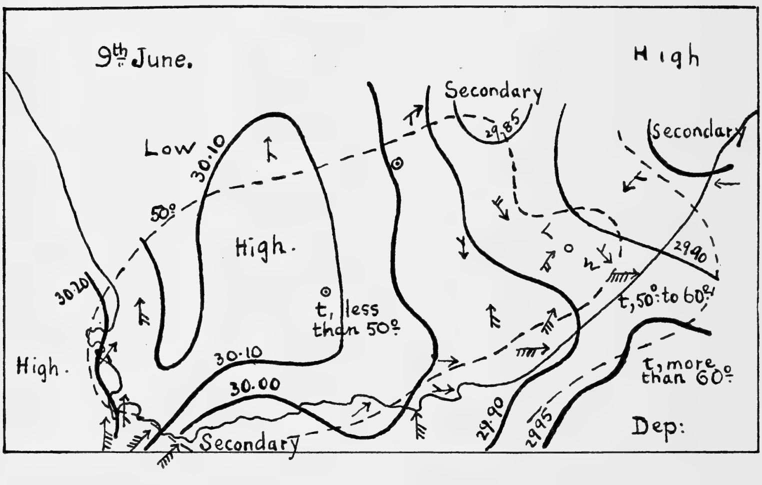
With a view to ascertaining what weather conditions existed at and prior to the dates given, the writer has carefully studied the distribution of pressure, direction of wind, &c., with the following results:—

On the 7th it was seen that a depression was approaching from the south-west, moving towards the south coast, and that it would pass to the east of Cape Agulhas. It passed that station on the same evening, but affected the Observatory very little, except by causing some rain to fall. On the morning of the 8th it was passing along the coast and was followed by a "high." During the night of the 8th–9th a secondary passed Cape Agulhas, and was seen to be off the south coast on the morning of the 9th. This was opposed by the lower limit of the equatorial tongue of low pressure, and snow fell at Caledon, Concordia, &c. On the 8th the equatorial tongue had developed energy, and was being pushed to the east by the "high." As it pressed against the Transvaal anticyclone it brought down warm, moist north winds. On the 9th the Transvaal anticyclone had moved to the east, the northerly depression had separated, one part becoming an entity and resting over the Free State, while the tongue was weaker. The southern inverted V depression joined forces with the Free State subsidiary cyclone, and a secondary had formed in the Transvaal

SYNOPTIC CHART.

ILLUSTRATING THE BLIZZARD, JUNE, 1902.





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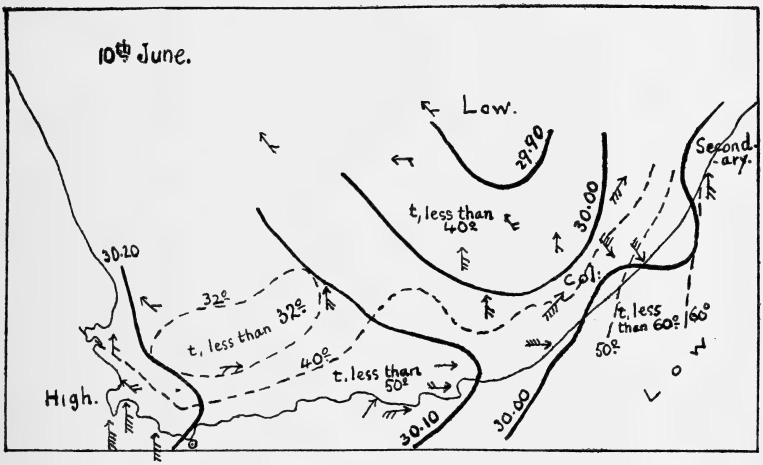
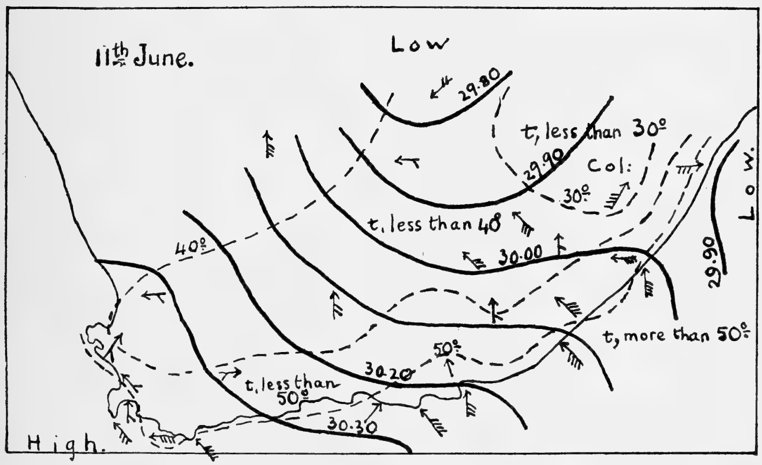




anticyclone over Natal. Cold southerly winds replaced the warm northerly ones. The conditions were for thunder, rain, and snow.

On the 10th the "high" spurred along the south coast, and the eastern "lows" had yielded. The narrow "col" over the Transkei indicated thunder and rain. The cold southerly winds over the east kept up the snow conditions. The Natal secondary now rested over the eastern ocean. Everything pointed to a general clear up, but with a continuance of cold winds. On the 11th the general winds were south-east along the advance northern edge of the moving anticyclone, which was travelling from WNW. to ESE.; the "col" was widening, but the equatorial tongue had intensified, and there was no indication of a rise in temperature. On the 12th a cyclone was over the Indian Ocean to the east of Natal; this surged back the isobars and caused the Transvaal anticyclone to retreat to the WNW. The equatorial tongue had been almost obliterated; meanwhile the moving anticyclone was well to the south of the land, and the Namaqualand one was re-forming and pressing over the Interior, helping to diminish the width of the low-pressure tongue. The effect of encroaching high pressure from the west and the surge back of the "low" from the east increased the gradients and brought very strong southerly winds and low temperature.

On the 13th all the "lows" had gone, and the Transvaal anticyclone and the Namaqualand one were connected by a high "col," while the moving "high" had left the land and was evidently over the south-eastern ocean. Conditions were for fine, clear, cool weather, and, for a short time at any rate, cold winds.

There is no doubt that the cyclone of the 12th came from the Indian Ocean. It must have been just recurving, and the fact that the moving anticyclone passed to the south of the Cape in an ESE. direction (most unusual for June) allowed the cyclone to touch Natal. Had this not happened there would have been a clear up on the 12th.

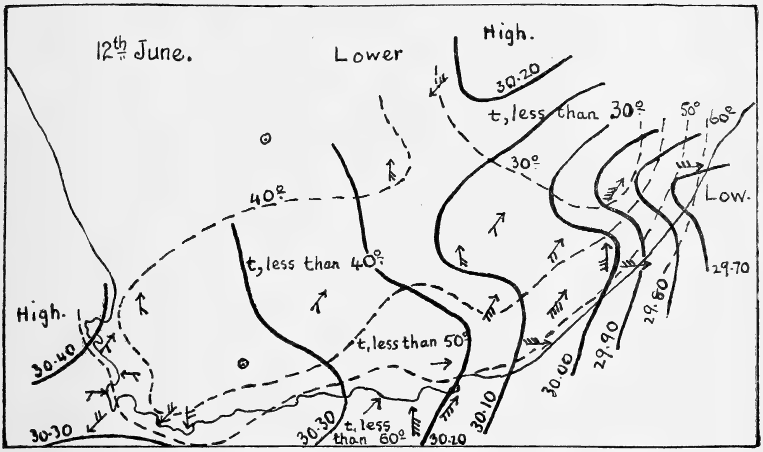
Without doubt moisture was carried from the east coast, round the Transvaal anticyclone, and brought by northerly winds over the Transvaal as far as the east of the Cape. The advent of the cold southerly wind on the 9th brought rain, and the temperature at various places falling below freezing-point snow was a natural consequence.

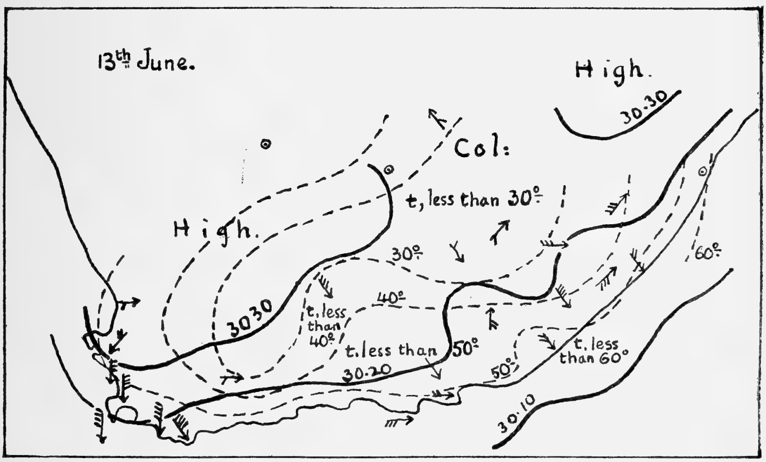
To further illustrate this. On the morning of the 8th temperature was 60° at Queenstown, 61° at Stutterheim, 60° at Graaff Reinet, 69° at Somerset East, and 68° at King William's Town. On the morning of the 10th these were 38°, 40°, 41°, 40°, and 45°, and, with slight fluctuations, this low temperature was maintained until the 13th.

It is very strange that the more elevated stations did not feel the effect of the warm wave so much, nor did the full effect of the cold wave appear until the 10th. Thus, on the morning of the 8th temperature was 49° at

SYNOPTIC CHART.

ILLUSTRATING THE BLIZZARD, JUNE, 1902.





Kimberley, 49° at Hope Town, 49° at Steynsburg, 45° at Doorn Kop, and 52° at Kilrush. On the morning of the 9th these were 54°, 48°, 43°, 49°, and 52° respectively, but on the morning of the 10th the readings were 38°, 40°, 34°, 34°, and 37°, and it decreased during the following days.

It is evident by this that the cold from the southern ocean cooled the atmosphere progressively from the coast northwards and vertically. This may account for the fact that the greater falls of snow began on the 10th.

Interest in the foregoing is enhanced by the fact that snow-storms have visited South Africa on other occasions, when similar conditions have prevailed, and it is safe to say that during the season when snow can be expected these conditions are almost sure to prefigure snow. Of course this is not the only condition foretelling snow, but, as far as has been seen, the only one causing a blizzard.

The thanks of the writer are due to Mr. C. B. Stewart, now Chief Meteorologist to the Union, for supplying the data necessary for the preparation of the Synoptic Charts.

THE LEAF-SPOTS OF *RICHARDIA ALBO-MACULATA*, Hook.

By W. T. Saxton, M.A., F.L.S.

(Read August 21, 1912.)

The genus *Richardia* includes six species, of which two are characterised by the presence of peculiar white streaks on the leaf lamina. These two are *R. albo-maculata* and *R. melanoleuca*, Hook. f. In the mature leaves there is no apparent difference between the spots in the two species and it is very probable that the devolopment is the same in both. Material of young leaves of *Richardia albo-maculata* was collected in December, 1911, during a botanical expedition in the Transkei,* with a view to

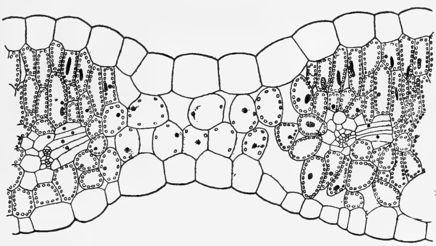
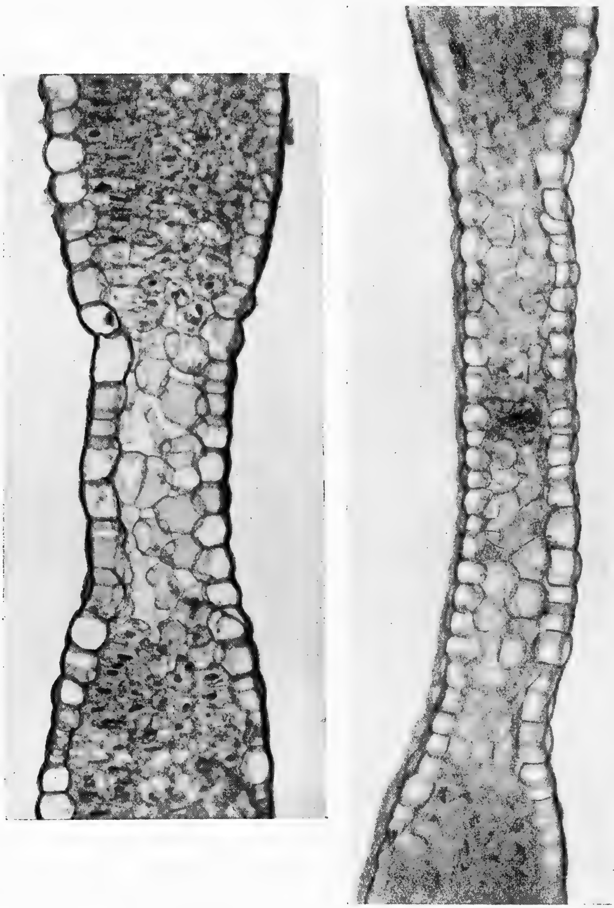


Fig. 1.—Drawing of a transverse section across the smallest white streak seen on a leaf of *Richardia albo-maculata*. × 130.

investigating the origin of the white spots on the leaf. The material was collected near Kentani, and I am glad to take this opportunity of thanking Miss Pegler for her kindness in taking me to the best collecting localities in that neighbourhood.

It was observed that the white streaks, so conspicuous in the mature leaf, were both smaller and less conspicuous in young leaves, while in the

* With the aid of a research grant from the grant committee of the Royal Society of South Africa.



FIGS. 2 & 3.—Microphotographs of transverse section of older stages of the white spots on leaves of *Richardia albo-maculata*. × 130.
(*Photograph by H. Gunnery.*)

youngest leaves that could be found they were entirely absent. It was further noted that the white patches were always thinner than the rest of the leaf. The appearance, as seen with a hand lens, suggested that the epidermis had split apart in these regions; but this explanation proved to be erroneous.

Material was fixed in 90 per cent. alcohol, to show the youngest stages of the streaks which are visible to the naked eye, and a series extending from these up to nearly full-sized patches. The size of the youngest visible patches was about ·3 or ·4 mm. long by about ·15 mm. wide. A section across such a patch is shown in Fig. 1. The reason why the leaf is thinner in the white region is now evident; the palisade parenchyma has completely disappeared, and only the spongy mesophyll lies between the upper and lower epidermis. It is also seen that very few plastids occur in the cells of this region. It is probable that those which do occur are of the nature of leucoplasts, though it is not possible to distinguish them structurally from the numerous chloroplasts of the green tissue.

Fig. 2 is from a microphotograph of a somewhat later stage, in transverse section, and Fig. 3 represents a transverse section of a patch which has attained almost its full size. From the structure of these later stages, in which a much larger number of mesophyll cells is seen in the thin part of the section, the conclusion seems unavoidable that divisions must take place in these cells, in the plane of the leaf lamina, thus increasing the size of the patch. Corresponding divisions must also occur in the epidermal cells. At the time of fixing the material it was not contemplated that any cytological details would be required in investigating the structure, and consequently a cytological fixative was not used. It is therefore not surprising that no nuclear divisions have been seen; nor are the nuclei of the epidermal cells visible, except in a few cases. For purposes of comparison pieces of young leaves of *Richardia africana* have been carefully fixed and sectioned, and here it has been found that the nuclei are present in all the epidermal cells, apparently in a perfectly healthy condition, though the cytoplasm is very scanty. It is likely that cytologically fixed material of *R. albo-maculata* would show them also.

It is less easy to explain how the patch first arises than to trace its subsequent development. It seems probable that certain cells in the mesophyll become actively meristematic, a condition which does not extend to the palisade, but which is duplicated in both upper and lower epidermis. This would cause a splitting apart of the palisade in the centre of such a group of meristematic cells, resulting in the structure already described.

Variegated leaves are, of course, quite a common phenomenon, though most frequently met with in cultivated plants. In such leaves, however, the variegations are not usually accompanied by any differences in thickness or structure, other than the distribution of plastids and pigments. As far as the writer is aware, no case similar to that now described has been previously recorded.

It is quite conceivable that the well-known leaves of *Monstera* (also belonging to the *Araceæ*) may have been derived from a type of leaf similar to that of *Richardia albo-maculata*. In *Monstera* portions of the leaf lamina dry up and break away entirely, and an epidermis is then formed round the edges of the hole thus produced.

In one respect the leaf of *R. africana* has been found to be very different from that of *R. albo-maculata*, namely, in the size of the intercellular spaces in the spongy parenchyma. In *R. africana* these are very large and numerous, and the most conspicuous feature in a section of the leaf, being bounded only by trabeculæ, in the form of chains of mesophyll cells; in *R. albo-maculata*, on the other hand, the intercellular spaces, as seen in section, seldom exceed the dimensions of a single mesophyll cell, and are not at all a conspicuous feature of the anatomy. In other respects the leaf structure is very similar in the two species, and shows no other noteworthy peculiarities.

My thanks are due to Mr. Z. J. de Beer, who prepared the sections from which the photographs were taken.

ON THE SALIVARY AND MOUTH GLANDS OF THE NUDIBRANCHIATA.

By T. F. Dreyer, B.A., Ph.D.

(Read August 21, 1912.)

The Nudibranchs always have at least one pair of glands in connection with the anterior part of the alimentary canal—the salivary glands. They may, however, have another pair entering the mouth; these are of unknown function and are sometimes called ptyaline glands. It would be preferable, I think, to call them mouth glands until their function is known. It has been conjectured that the mouth glands may secrete a defensive juice, but as I have never observed a Nudibranch to turn its head towards a point of irritation—the papillæ are turned in that direction—this view cannot well be maintained. A more likely hypothesis is that the mouth glands secrete a fluid capable of dissolving the hard parts, calcareous or chitinous, of the Hydromedusæ on which the "slugs" feed.

Fig. I. represents the anterior portion of the alimentary canal and the attached two pairs of glands as seen in a dissection of *Spurilla neapolitana* ; it is a dorsal view. The mouth gland of the left side E joins with its fellow of the opposite side—underneath the mouth—to form a common median duct which almost at once enters the mouth cavity A; the salivary gland D runs over the dorsal surface of the crop C, along the œsophagus and into the pharynx B; the ducts of the salivary glands run downwards and forwards in the muscles of the pharynx and enter the pharyngeal cavity separately, one on each side near the base of the tongue. The salivary glands, or their ducts, pass through the nerve collar.

Other animals studied by means of serial sections are: *Doto fragilis*, *Faceline Drummondii*, *Berghia*, *Calma Cavolinii*, *Coryphella*, *Rufibranchialis*, *C. lineata*, *Tritonia plebeia*, *Marionia*, *quadrilatera*, *Favorinus-albus*, and *Rizzolia peregrina*. Only *Spurilla*, *Doto*, *Facelina*, *Berghia*, and *Calma* have mouth glands.

The salivary glands have the histological structure typical for such glands; they only vary in size and position in the various genera. The usual position for them seems to be in the body wall just underneath the first right and left bundles of dorsal papillæ. The salivary glands have this position in *Coryphella, Berghia, Favorinus,* and *Rizzolia.* In *Spurilla* they end in the body wall underneath the first bunch of papillæ, but the greater portion of the glands lie on the œsophagus and crop. In *Calma* the position is as for *Spurilla.* In *Tritonia* the salivary glands are short, stout structures lying along the œsophagus. In *Marionia* and in *Doto* the glands are voluminous and are spread around the posterior end of the pharynx. The ducts of the salivary glands pass, as already mentioned

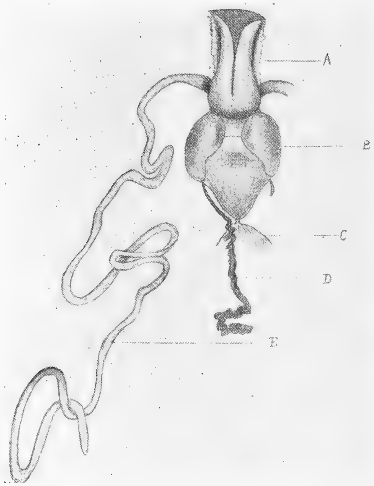


Fig. I.

along with œsophagus through the nerve chord; they are extremely delicate and may have a diameter of even less than ·005 mm.

The mouth glands agree in opening into the mouth cavity, but in nothing else. In *Calma, Spurilla, Berghia,* and *Facelina* there are right and left portions opening into a common duct which lies mid-ventrally to the pharynx. In *Doto,* however, there is only a left gland. In the others the glands are throughout their lengths muscular, or at least the common duct is muscular. In *Doto* the "reservoirs" of the gland are not muscular and neither is the median duct. In *Doto* the gland is acinose—in the others the glands are tubular.

Secretory cells of the mouth glands are very diverse in histological structure; they sit on the tubes or reservoirs either singly (*Spurilla* and *Doto*) or in groups of three or four (*Facelina*). They are always enveloped in a delicate connective tissue sheath the nuclei of which can be seen in Fig. II. and Fig. VI. 1. A comparison of Figs. IV. and VI. will show the absolutely different structure of the glands. The cells of *Facelina* can be described as follows: Nucleus large, poor in chromatin, rich in nuclear fluid, with large paranucleus; protoplasm with numerous deeply staining (iron-hæmatoxylin) spherical secretory globules which are seen to escape as minute drops into the lumen of the tube on which the cells sit; a

Fig. II.

portion of the protoplasm (Fig. IV.) near the base of the cells is free of globules. Fig. III. shows a group of cells (1 and 2) in active secretion, and another (3) apparently recuperating after a period of secretion.

The secretory cells of the mouth glands of *Doto* are remarkable in many ways. They are of enormous size, having diameters of up to ·4 mm. The nuclei are also enormous (Fig. VI. 2); they have a number of large karyosomes but no nucleoli. The protoplasm shows an unusual structure; there are two layers having a regular fibrillar structure—one layer immediately around the nuclear membrane and a peripheral layer; in cell 2 of Fig. VI. these two fibrillar layers are seen to be continuous at the point where the secretion is discharged from the cell. In cell 4 of the same figure the perinuclear layer is seen in surface view, the section being one taken just before that in which the nucleus is cut into. The protoplasm also contains a reticulum of darker stained substance which is also aggregated in irregularly shaped masses. Other curious points are that there appear to be no separating membranes between the secretory cell

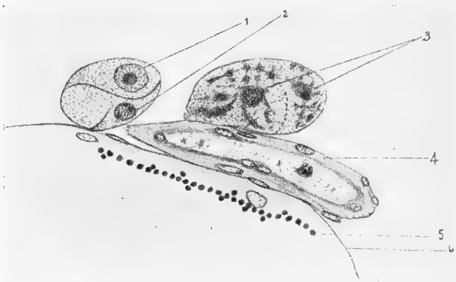


Fig. III.

and the adjoining cells of the "reservoir" and that the fibrillæ of the protoplasma of the secretory cell is continuous right through the cells of the reservoir. One would, of course, expect to see the secretory cells discharging by means of a neck situated in between the epithelial cells, but the glandular cell has apparently reached such an enormous size and such

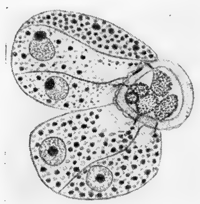


Fig. IV.

an active stage of secretion that it simply "drowns" the adjoining cells. This can be seen in a number of sections and the cells in the neighbourhood of the point of discharge of a secretory cell is always smaller and darker than those further off. The secretion is apparently discharged in a *continuous thin stream.* In the reservoirs it then takes the form of globules two of which are seen in the reservoir labelled 3 of Fig. VI.

In *Spurilla* the secretory cells resemble those of *Doto* rather than those of *Facelina*. Fig. II. shows such a cell with the nucleus at one end and the streamlets of secretory fluid running to the neck. The cells of *Calma* resemble those of *Facelina*. In the last-named animal we see three phases of secretion represented in Figs. III. and IV. Fig. IV. represents the cells in active function; cells 1 and 2 of Fig. III. shows the phase immediately prior to activity, and cell 3 of the same Fig. is probably the phase after a prolonged period of activity; there are two such cells, the nuclei of which are labelled 3; the nuclei are of irregular shape and indefinite outline and resemble the nucleus of the *Spurilla* cell (Fig. II.), but the two cannot represent equivalent phases since Fig. IV. represents the actively secreting cells of *Facelina*, and Fig. II. shows that also the *Spurilla* cell is in full activity.

The secretory cells of the mouth glands are thus of at least three types one, nucleus large and clearly defined, no nucleolus, perinuclear and peripheral fibrillæ of secretory fluid; two, nucleus large but rich in chromatin and irregularly defined, secretory fluid as streamlets between nucleus and neck of cell (*e.g.*, *Spurilla*); three, nucleus comparatively small, poor in chromatin; large nucleolus; secretion in form of globules scattered in form of large sphere around the nucleus and discharged through a minute neck.

If the secretory cells of the mouth glands show a diversity of structure, the tubes or reservoirs into which they discharge show an even greater diversity. I have already mentioned that the mouth glands are usually present as right and left halves opening into a common median duct running ventrally to the pharynx and opening into the mouth. The first point to be noticed is that the several Eolidids possess tubular mouth glands, whereas *Doto fragilis* has an acinose gland. The second point is that the tubes, or at least the common median ducts, are muscular, whereas in *Doto* there are no muscle fibres either in the walls of the separate alveoli nor in those of the median duct. The third point of difference is that in *Doto* the mouth gland is only represented by a left bunch of alveoli or reservoirs, the right having no chance of any great development since the available space on the right side is taken up by the genital organs. Besides the bunch of alveoli of the left side there is a glandular tube which opens into the median duct at the posterior end of the latter; it runs forwards with the median duct, lying on the dorsal surface of the latter and ending blindly just posterior to the opening of the median duct into the mouth. This outgrowth is composed of cells which are all glandular and has thus a structure not at all comparable to that of the mouth gland as exemplified by the left lobe, but it may nevertheless be the mouth gland of the right side which has not been developed owing to want of space.

The structure of the tubes must be described separately. Fig. V. shows two slightly oblique sections through the tubes of the mouth gland in the region underneath the first bunch of papillæ; a muscle fibre cell is seen running from the one to the other and the nuclei and plasma of other such cells are seen in cross-section surrounding the tubes. The tubes and muscle fibres are enveloped in an exceeding delicate sheath of connective tissue which is not seen in the drawing. The tubes themselves are shut in by a single layer of cells and have somewhat irregular lumina. The cells are of a peculiar structure and must be compared with the muscular epithelia of Hydra; the part of the cell towards the lumen is composed of clear protoplasm in which lies the nucleolated nucleus where-

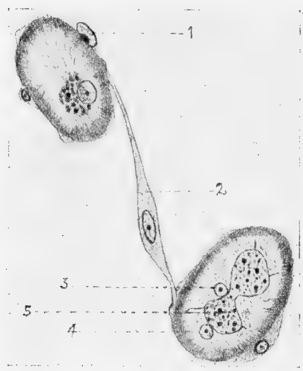


Fig. V.

as the peripheral part is striated. It may, of course, be that the striæ represent the secretion, but, as they are neither in the neighbourhood of the nucleus nor the lumen, this is not likely. It is probable that the striæ are muscle fibrillæ, stretched from centre to periphery, by means of which the tube may be compressed or dilated in order to force the secretion along the tube to the exterior.

The tubes of the mouth glands of *Spurilla* are extremely muscular (Fig. III.). The Fig. represents the best section which I could find and is not good although I even went to the pains of dissecting out and preserving for themselves these glands. On the outside are seen two secretory cells, then comes a layer of neutral cells, then a thick layer of muscle fibres very sparsely nucleated (one longish, dark nucleus can be seen on the inner side in the Fig.) and lastly, another layer of neutral cells in which are large vacuoles which may have been filled with the secretion. The whole structure is enveloped in connective tissue which can be seen as a delicate membrane around the contracted secretory cells.

The tubes of *Calma* are very similar to those of *Facelina;* those of *Berghia* resemble to some extent those of *Spurilla.*

The structure of the alveoli of *Doto* is quite distinct. The whole organ is again enveloped in connective tissue, nuclei of which can be seen at the

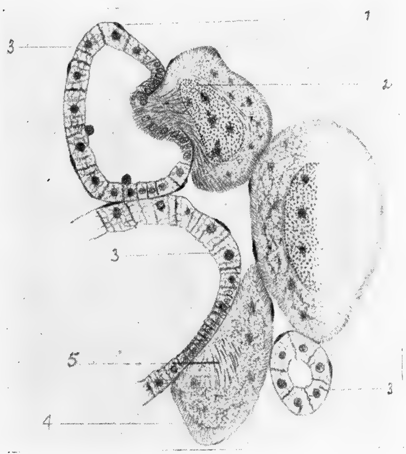


Fig. VI.

points marked 1 in Fig. VI. Each alveolus is composed of a single layer of epithelial cells, each of which has a fair-sized nucleus and a coarsely reticulated protoplasm ; the dividing cell walls are wavy in section which is due to the points of attachment of the reticulum drawing the walls now this way then the other. The cells in the neighbourhood of a secretory neck are small and stain darkly, whereas those further off are fairly large (ten or more times as large as former) and only the nuclei and reticulum are deeply stained.

EXPLANATION OF FIGURES.

FIG.

I. Dorsal view of the alimentary canal of *Spurilla neapolitana;* A = mouth; B = pharynx; C = crop; D = Salivary gland of left side; E = mouth gland of same side. From a dissection.

II. Cross-section of a piece of the mouth gland of *Spurilla.* 1 = lumen of tube; 2 = secretory cell with nucleus 3; 4 = nucleus of connective tissue envelope; 5 = muscle layer with a nucleus; 6 all the sections are stained with iron-hæmatoxylin.

III. Cross-section of mouth gland of *Facelina Drummondii.* 1 and 2 are cells before (?) secretory activity; 3 are nuclei of cells after (?) prolonged activity; 4 = tube with nuclei in wall; 5 and 6 parts of neighbouring receptaculum seminis.

IV. Cross-section of same as Fig. III. The cells are here shown in full function.

V. Same as III. and IV. but is taken where no secretory cells are attached. 1 and 2 muscle cells; 3 and 4 nuclei of wall cells of tube; 5 lumen of tube with secretion.

VI. Section of mouth gland of *Doto fragilis.* 1 = connective tissue nuclei; 2 = nucleus of excretory cell; 3 wall of alveoli; 4 = peripheral striated layer of secretory cell; 5 = perinuclear striated layer.

A LIST OF SOUTH AFRICAN LACERTILIA, OPHIDIA, AND BATRACHIA IN THE McGREGOR MUSEUM, KIMBERLEY; WITH FIELD-NOTES ON VARIOUS SPECIES.

By J. Hewitt and J. H. Power.

(Read August 21, 1912.)

This paper is primarily intended as a contribution to our knowledge of the fauna indigenous to the Kimberley neighbourhood.

The fauna of the district has no doubt been somewhat modified during the last few decades. Formerly the veld was dotted over with clumps of trees and had a park-like aspect, while in parts the bush was even thick. To-day, however, the Kimberley neighbourhood is comparatively bare, its trees having been extensively cut down by the early diggers.

Probably as a result of denudation, the present-day indigenous fauna is rather small in comparison with that of other towns in South Africa. On the other hand, the occupation of man has served to introduce a new fauna, for along with the firewood brought into Kimberley from various parts of the line through Bechuanaland to Rhodesia, there has been accidentally introduced a number of sub-tropical species which are not indigenous to the district. The foreign species have been clearly indicated as such on our lists.

We have also added some field-notes on the habits of the various species, hoping that such data, apart from their intrinsic interest, may throw some light on the question of the evolution of species through habitudinal or physiological isolation.

The Kimberley Museum has also much material from other parts of South Africa, including an exceptionally fine collection of reptiles brought back by Miss Wilman from her trip in Gordonia made in company with Miss D. Bleek in October and November of last year. Miss H. Lennox accompanied the expedition, which was conducted by Mr. G. St. L. Lennox, of Upington.

The party left Upington early in October, but as the weather was at first unusually cold no reptiles were seen till Gousis, on the Molopo River, was reached. This farm is a little to the north of Smalvisch Kop, shown on most maps of Gordonia.

From here the trek was along the bed of the Molopo River up to its junction with the Kuruman River, and the large number of lizards found both there and on the return journey were labelled "Lower Molopo."

The expedition next proceeded up the Nosob River as far north as the boundary of Kyky and Sequats. This proved a good collecting ground, and specimens taken during this part of the journey were labelled "Nosob."

At Kyky, on the Nosob (about 26° S.), a stay of some days was made, and during that time lizards and snakes (which had only now become plentiful) were brought in from all sides, including the Bechuanaland Protectorate, by Bushman collectors. These were labelled "Kyky."

On the return journey, the weather being warmer, a number of specimens were taken between Gousis and Upington, at Grond-Neus, Blauwbosch, Geluk, Wildehonde Pan, &c.

The collectors were Mr. and Miss Lennox and Miss Wilman, and they are alluded to below as "L. W."; the field-notes are contributed by Miss Wilman.

With the exception of species that were described after the publication of Mr. Boulenger's monographs on the various families of reptiles and batrachians, in the British Museum catalogues, references are only given to the descriptions in those catalogues. Further references may be found in Mr. Boulenger's "Revised List of the South African Reptiles and Batrachians," published in the Annals of the South African Museum, vol. v., part ix., 1910.

We are under a great obligation to Miss Wilman, Curator of the Museum, not only for permission to use the material under her charge, but also for active co-operation in the compilation of these lists, and for much information bearing on the matter contained herein.

The following are some of the localities referred to below :—

German S.W. Africa: Okavango R.

Southern Rhodesia: Eldorado, Lomagundi District; Chisagwasha, near Salisbury; Marandellas; Insiza; Bembesi.

Bechuanaland Protectorate: Tati District (Francistown); Mochudi; Gaberones; Baralong Farms (N.W. of Ramathlabama).

Transvaal: Middelburg; Zeerust; Christiana.

Orange Free State: Winburg (Ventersburg); Bloemfontein (Immigrant); Jacobsdal; Fauresmith.

British Bechuanaland: Mafeking (Madibi, Kraai Pan, Wirsing, Mosita); Vryburg (Genesa); Kuruman; Taungs; Gordonia (Springbok Vlei, north of Abiaru).

Cape Colony: Barkly West (Fourteen Streams, Waldek's Plant), Vaal R. Diggings; Kimberley (Riverton, Dronfield, Modder R., Riet R.); Herbert; Colesburg; De Aar; Hanover; Victoria West; Oudtshoorn; East London; Port Elizabeth; George (Kaaiman's R.); Paarl; Stellenbosch (Somerset Strand, Gordon's Bay); Cape (Kalk Bay, Muizenburg).

When the locality is a farm or a mine, the district in which this is situated is added.

Part I.—LACERTILIA.

Family GECKONIDÆ.

Chondrodactylus angulifer Pet.; B.M. Cat., I., 11.

Blauwbosch, Gordonia (L. W.); Victoria West (P. D. Morris).

Ptenopus garrulus (Smith); B.M. Cat., I., 15.

Kyky and Nosob (L. W.).

Its characteristic call, which commenced before sunset and continued throughout the night, was also heard on the Molopo River and on the south bank of the Orange River at Upington.

Known to the Hottentots as "T'kan T'kan," and considered deadly poisonous (H. Drew).

Phyllodactylus porphyreus (Daud.); B.M. Cat., I., 87.

Kalk Bay (J. C. Moran).

Thirteen eggs were found in a small cavity in the side of a rock, covered with sand and moss.

Hemidactylus mabouia Mor. de Jonn.; B.M. Cat., I., 122.

Bushman Mine, N.W. Bech. Prot. (H. McLelland.)

Lygodactylus capensis (Smith); B.M. Cat., I., 160.

Eldorado (O. A. Kidwell); Mafeking (A. H. Wallis); Madibi (F. B. Parkinson); Taungs (P. Court); Kimberley (J. H. Power, C. Turpin).

Common in the neighbourhood of houses in the Transvaal and in Griqualand West. It is naturally an arboreal lizard.

HOMOPHOLIS WAHLBERGI (Smith); B.M. Cat., I., 191.

Gaberones (B. Perfect).

PACHYDACTYLUS BIBRONI (Smith); B.M. Cat., I., 201.

Eldorado (O. A. Kidwell); Francistown (C. Butler, H. McLelland); Kyky, Lower Molopo (L. W); Upington (Miss Lennox); Taungs (P. Court); Kimberley (T. Lee, A. and E. Maltman, J. H. Power); Rooidam, Kimb. (G. Gain); Fort Richmond, Herbert (W. H. Wayland).

Some of the Gordonia specimens have stellately keeled dorsal tubercles, agreeing with Werner's variety *stellatus*, but the variety is not likely to have a geographical significance.

Though not generally a domestic lizard, this species was sometimes taken in native huts in Gordonia. It is common on the kopjes near Kimberley.

PACHYDACTYLUS CAPENSIS (Smith); B.M. Cat., I., 202.

Mafeking (A. H. Wallis); Kraai Pan (S. D. Smith); Taungs (P. Court); Kuruman (C. E. Wimble); Kyky (L. W.); Kimberley (F. Diebel, N. Neville, C. Orton, J. H. Power); Karreeboom, Kimb. (Mrs. McIntyre); Kalk Bay (J. H. Power).

The scaling of the dorsal surfaces varies widely in immature examples, so that we are not satisfied that *P. affinis* Boul. is really distinct from *P. capensis*.

Another form has been recently described by Dr. R. Sternfeld from Bethany, O.F.S, and from Griqualand West under the name of *P. leopardinus* Stern., but that is almost certainly merely a juvenile *P. capensis* (see Mitt. d. Zool. Mus. Berlin, v., 3, 418).

The eggs of this gecko are found under stones usually glued together in pairs, their longer axes often at right angles to each other. The egg measures 11 × 8 mm.

PACHYDACTYLUS RUGOSUS Smith; B.M. Cat., I., 204.

Kyky (L. W.).

PACHYDACTYLUS MARIQUENSIS Smith; B.M. Cat., I., 207.

Kimberley (J. H. Power); Alexandersfontein, Kimb. (J. C. Moran).

FAMILY AGAMIDÆ.

AGAMA HISPIDA (Linn.); B.M. Cat., I., 349.

Somerset Strand (J. H. Power).

AGAMA DISTANTI Boul., Ann. Mg. Nat. Hist. (7), IX., 339.

Eldorado, Marandellas (O. A. Kidwell); Mochudi (W. A. H. Harbor); Baralong Farms (F. B. Parkinson); Mafeking (A. H. Wallis); Madibi (F. B. Parkinson).

AGAMA ACULEATA Merr.; B.M. Cat., I., 351.

Kyky, Nosob, Lower Molopo, Wildehonde Pan, Upington, (L. W.); Kimberley (R. C. Barrow, H. A. Black, A. L. Franceys, H. C. Perring, J. H. Power, C. E. Weston, W. Wright); Fort Richmond, Herbert (W. H. Wayland).

The systematics of the *hispida* section of *Agama* have been dealt with by various authors, with results which are somewhat conflicting. The most recent proposition (Sternfeld in Mit. a. d. Zool. Mus. Berlin, v., 3. 398) is to sink all our species into *hispida*, but this seems to us unjustifiable. It is possible that *brachyura* and *distanti* will be found to grade into *hispida*, but even in such case it will be desirable to retain the names as geographical varieties. *A. aculeata* seems to be a good species, characterised by the distinct and uninterrupted dorsal crest and by the relative proportions of the toes. Yet some of its characters grade with those of *distanti*. A half-grown specimen from Kraai Pan has the third toe distinctly longer than the fourth, and the dorsal crest, though continuous, has some of its scales enlarged; a half-grown example from Taungs has the third and fourth toes subequal; an immature specimen from Serowe (Albany Museum) has the general appearance of *aculeata*, but the third toe is longer than the fourth. In each of these cases the fifth toe is appreciably longer than in the typical form of *distanti*. It is significant that these all came from the borderland between the headquarters of the two species; no such intermediates, if they may be so called, were found in the large collection of *aculeata* made in Gordonia. We are not in agreement with the proposal of Dr. Werner and Mr. Boulenger to completely unite *aculeata* and *armata*, as those forms will most probably have a geographical meaning; at any rate the very large collection in the Kimberley Museum is made up entirely of *aculeata*, *sensu strictu*.

Dr. Schultze found this species widely distributed in the Kalahari, and at one locality, Okahandja, according to Dr. Werner, *hispida* (presumably *distanti*) was also found; but the latter species was not found in Miss Wilman's Kalahari collection. The specimens recorded in Annals Transvaal Mus., vol. iii., 47, from Kimberley, Tafelberg, and Cradock belong to *aculeata* not to *brachyura*.

Agama aculeata, commonly called the "blauwkop kochelmander," is fond of perching on the tops of thorn-trees and shrubs, but also lives on the ground. It is remarkable for the magnificence of its colours and for the variability in colouration during excitement or in response to different environments.

On the ground the adults often remain quite motionless on the approach of man, for the general colour is a dull dark brown or dull uniform grey, very much in accordance with the prevailing colours of the surroundings; the young ones are paler and have a more or less distinct colour pattern, the shades of which vary with the surroundings. At other times, especially in trees, they show the most gorgeous hues and splendent lustre. Miss Wilman, who saw them on bushes in the Kalahari, writes: "They were so brilliantly coloured that even from a distance they resembled huge splendid flowers—in fact I never saw more wonderful colouring, even in parrots or other birds."

In the breeding season the breast and sides of the abdomen become brick-red, the head acquires a vivid blue colour, and the scales near the vertebral line assume divers shades of blue, purple, and red; the throat becomes bluish black, or white with wavy black lines, and develops a distinct pouch which hangs down conspicuously. When teased the colours in general, within a minute or so, become more vivid, and in females especially a regular colour pattern becomes definitely marked out dorsally, whilst a double row of scarlet blotches appears along the back; in these blotches the colour extends even to the tips of the scales. This pattern is fairly uniform, and is of the same type as that of *distanti* or *brachyura*.

They will also make appropriate colour changes when placed in dark or light environments.

Though the adults are not particularly shy, and often slow of movement, the juveniles are very quick.

When molested they are apt to inflict a deliberate and painful bite. Two males engaged in a fight were observed on September 9, 1911: the vertebral crest from head to tail was strongly and acutely erected, whilst the gular fold, almost black in colour, was inflated to about three times its normal size. Near Kimberley they pass the winter under stones or old tins on the open veld. Hibernation, which is long and deep, takes place on the first approach of cold weather.

This species is both insectivorous and herbivorous; it is often found impaled on thorn-trees, a victim of the butcher-birds.

Externally they are often infested with small scarlet ticks, sometimes in great numbers.

The eggs number from fourteen to seventeen, and measure about 14 × 10 mm., being oval and not calcareous.

AGAMA ATRA Daud.; B.M. Cat., I., 352.

Taungs (P. Court); Immigrant (R. B. Eve); Riverton (G. Messine); Kimberley (R. F. Fitzpatrick, J. H. Power, T. R. Sefton, M. Terents);

Rooidam, Kimb. (G. Gain) ; Fort Richmond, Herbert (W. H. Wayland); Victoria West (P. D. Morris); Oudtshoorn (J. L. Cairncross); Gordon's Bay (J. H. Power).

This lizard inhabits rocky localities, being common on the Kimberley kopjes, where it lives along with *Zonurus polyzonus*, which in winter may be found hibernating in the same cleft therewith. It is very alert and shy. Only to a very slight extent can it change colour on irritation, but in different districts it may show great differences in colouration; the gorgeous hues of some specimens taken at Gordon's Bay in December, 1910, quite surpass those of Kimberley examples in their breeding attire. The colours of the breeding male are as follows: under-surfaces a glowing ultramarine blue, the sides of the body reddish brown or purple, and of the tail a rich lemon colour, the dorsal surfaces varying shades of pink, but usually dark, often covered with dots, which sometimes form a network; sometimes the dorsal surface has brown ocelli on a lighter background, and there may or may not be a pale median band. The eggs are similar in size and number to those of *aculeata*, and, like it, this species is both herbivorous and insectivorous.

Agama kirki Boul., B.M. Cat., I., 354.

Marandellas (O. A. Kidwell); Insiza (G. French).

Agama atricollis Smith; B.M. Cat., I., 358.

Marandellas (O. A. Kidwell); Francistown (C. Butler, H. McLelland).

The eggs measure 22 × 14 mm., and a clutch contains twelve to fourteen of them.

Family ZONURIDÆ.

Zonurus giganteus Smith; B.M. Cat., II., 253.

Ventersburg (F. Smith).

Zonurus cordylus (Linn.); B.M. Cat., II., 256.

Paarl (G. French); Kalk Bay (J. C. Moran, J. H. Power); Somerset Strand (J. H. Power).

Zonurus jonesi Boul., Ann. Mg. Nat. Hist. (6), VII., 417.

This species occurs at Kimberley (G. Gain, J. H. Power), but is not indigenous, as it is found only in the neighbourhood of the mines, and has undoubtedly been introduced from Bechuanaland along with the firewood used in the compounds.

ZONURUS POLYZONUS (Smith); B.M. Cat., II., 257.

Kimberley (A. Davis, L. McBean, W. Needham, F. Oats, J. H. Power); Rooidam, Kimberley (G. Gain); Riet Pan, Kimb. (Miss B. Reinhardt); Rust-en-vrede, Kimb. (Mrs. F. Vigne); Fort Richmond, Herbert (W. H. Wayland).

This species is common on the kopjes near Kimberley. They are very shy creatures, and when disturbed immediately retire to the clefts of the rocks, where they remain for a long time. In their hiding-places they turn the tail round to act as a shield. Though not at all vicious, they will occasionally attempt to bite if much irritated. They seem to be exceedingly attached to particular localities: not only do they occupy the same small area indefinitely, but even the same rock crevice serves as a permanent abode for many months. In the fierce heat of a summer's day they emerge to sit on the top of the heated rock, where, with belly pressed flat on the stone, the foreparts raised on the front legs, the head and neck almost upright, they remain for hours, only turning the head from side to side in response to sounds, or darting down occasionally to catch an unwary beetle or locust. When at rest they orientate themselves in accordance with the sun's rays, on hot days facing the sun but on cold days exposing their backs thereto. The habit of facing the sun throughout the day is said to be shared by *Zonurus giganteus* in the Free State, and the farmers speak of that lizard as the *Zon-kijker* (Sun-gazer). The diet is mainly insects of various kinds, but, on dissection, grass-stalks were found in the stomach of one specimen; another contained the remains of *Zonocerus elegans*, a very gaudy and ill-smelling grasshopper. The stomach and intestines are sometimes infested with nematodes. The tail is brittle and may break off at any of the joints, but the animal does not get rid of it unless roughly handled; after such an accident a new one, similar in thickness though not in scaling, is formed.

They seem to be of polygamous habits: in one locality nine females were found accompanied by only a single male. Males and females are easily distinguished externally through the femoral pores, which are only developed in the males. They breed early in September, and the young are born in January. The young are dirty white or grey, ornamented with small square and oblong black spots, and light bars at regular intervals across the tail.

The winter hibernation is neither long nor deep.

PLATYSAURUS GUTTATUS Smith; B.M. Cat., II., 262.

Insiza (G. French).

This species is united with *capensis* by Mr. Boulenger (Ann. S.A. Mus., v. 469), who includes all the known forms under that name. We hold that

P. guttatus Smith and *P. wilhelmi* Hewitt are distinct, and *P. capensis* Smith, which came from Great Namaqualand, may prove to be equally valid.

Family VARANIDÆ.

Varanus albigularis (Daud.); B.M. Cat., II., 307.

Marandellas (O. A. Kidwell); Madibi (F. B. Parkinson); Wirsing (L. Whiley); Vryburg (C. Terry); Kuruman (E. S. Chapman); Fourteen Streams (Mrs. Hunt); Kimberley (L. McCarthy); Wesselton Mine, Kimb. (C. E. Addams); Kenilworth, Kimb. (J. Liddel).

This giant lizard makes its home in trees or amongst rocks, but is a great wanderer and, unlike the water-leguaan, seldom stays long in one place. When attacked it takes refuge in holes or in trees, or even in water. It feeds on insects or birds' eggs, ravaging hen-roosts when available, and is said to kill and devour smaller lizards and snakes.

Varanus niloticus (Linn.); B.M. Cat., II., 317.

Riverton (Mrs. Hunt); Modder R. and East London (J. H. Power).

Of this lizard the largest example known to us slightly exceeds 7 feet in length: it came from Port Alfred (Albany Mus. coll.).

Family AMPHISBÆNIDÆ.

Amphisbæna quadrifrons Pet.; B.M. Cat., II., 447.

Mochudi (W. A. H. Harbor).

Monopeltis capensis Smith; B.M. Cat., II., 455.

Lower Molopo (L. W.); Karreeboom, Kimb. (Mrs. McIntyre); Barkly, West (R. Mansfield); Fort Richmond, Herbert (W. H. Wayland).

Family LACERTIDÆ.

Nucras tessellata Smith; B.M. Cat., III., 52.

Marandellas (O. A. Kidwell); Taungs (P. Court); Kyky, Nosob, Lower Molopo, as far south as Springbok Vlei (L. W.); Kimberley (F. Diebel, J. H. Power); Karreeboom, Kimb. (Miss O. McIntyre); Modder R. (J. H. Power).

All the Gordonia specimens belong to the variety called *forma typica* by Mr. Boulenger.

Occurs on the open veld along with *Eremias lineo-ocellata,* which it much resembles in habit.

ICHNOTROPIS CAPENSIS (Smith); B.M. Cat., III., 78.

Marandellas (O. A. Kidwell); Mochudi (W. A. H. Harbor).

ICHNOTROPIS SQUAMULOSA Pet.; B.M. Cat., III., 79.

Marandellas (O. A. Kidwell); Mochudi (W. A. H. Harbor); Kraai Pan (S. D. Smith).

EREMIAS LUGUBRIS (Smith); B.M. Cat., III., 84.

Francistown (C. Butler); Kyky, Nosob (L. W.).

EREMIAS CAPENSIS (Smith); B.M. Cat., III., 96.

Victoria West (P. D. Morris).

EREMIAS NAMAQUENSIS D. and B.; B.M. Cat., III., 91.

Kyky, Nosob, Lower Molopo (L. W.); Modder River (J. H. Power).

EREMIAS INORNATA Roux; Zool. Jahrb. Syst., XXV., 427.

Lower Molopo, Grond-Neus (L. W.).

Placed by Mr. Boulenger as a synonym of *undata;* by Dr. Sternfeld regarded as a variety of that species; we consider it a good species. It seems to be a rarity.

EREMIAS PULCHELLA Gray; B.M. Cat., III., 93.

Victoria West (R. Heberden).

Now sunk by Mr. Boulenger into the synonymy of *lineo-ocellata,* which undoubtedly is very closely allied. With full-grown specimens it should not be difficult to distinguish the two forms.

EREMIAS LINEO-OCELLATA D. and B.; B.M. Cat., III., 94.

Marandellas (O. A. Kidwell); Kyky, Nosob, Lower Molopo (L. W.); Emmaus (Y. Tournellec); Kimberley (G. McKay, J. H. Power).

The series from Gordonia is very extensive; only in the case of young specimens could they be confused with *pulchella.*

This species is common on the open veld, where it runs and turns with astonishing rapidity.

EREMIAS NITIDA Günth.; B.M. Cat., III., 83.

Eldorado (O. A. Kidwell).

This species has not previously been recorded from South Africa.

The single specimen differs from the description and figure of *nitida* as given in the British Museum Catalogue in the following respects: The lower posterior nasal not reaching the rostral; only about 25 transverse rows of scales ventrally. But for the keeled dorsal scales, it much resembles a *Nucras tessellata*, and, as noted by Mr. Boulenger, is a transition form between *Nucras* and *Eremias*.

SCAPTIRA DEPRESSA (Merrem); B.M. Cat., III., 110.

Kyky, Lower Molopo, Upington (L. W.).

These seem to be the most eastern records known for the species it was not taken by Dr. Schultze in the Kalahari.

FAMILY GERRHOSAURIDÆ.

GERRHOSAURUS VALIDUS Smith; B.M. Cat., III., 121.

Insiza (G. French).

GERRHOSAURUS FLAVIGULARIS Wiegm.; B.M. Cat., III., 122.

Taungs (P. Court); East London, Kalk Bay (J. H. Power).

TETRADACTYLUS SEPS (Linn.); B.M. Cat., III., 124.

Somerset Strand and Kalk Bay (J. H. Power).

FAMILY SCINCIDÆ.

MABUIA HOMALOCEPHALA (Wieg.); B.M. Cat., III., 170.

Somerset Strand and Kalk Bay (J. H. Power).

MABUIA QUINQUETÆNIATA (Licht.); B.M. Cat., III., 198.

Insiza (G. French).

MABUIA TRIVITTATA (Cuv.); B.M. Cat., III., 195.

Mafeking (A. H. Wallis); Madibi (F. B. Parkinson); Kimberley (R. C. Barrow, S. Cohen, G. McKay, H. C. Perring, J. H. Power); Karreeboom, Kimb. (Mrs. Hull, Miss M. McIntyre); Victoria West (P. D. Morris); Kalk Bay (J. H. Power).

It lives on the open veld, and is very common wherever it occurs.

The young, ten in number, are at birth still coiled up within the shell membrane. They are born in January or February.

MABUIA OCCIDENTALIS (Pet.); B.M. Cat., III., 196.

Kyky, Nosob, Lower Molopo, Wildehonde Pan, Grond-Neus (L. W.) Upington (Miss Lennox).

A very large series was collected but no variation whatever is to be found in the colour-markings. Not a single specimen of the closely allied species *trivittata* was obtained though it occurs in Great Namaqualand and is abundant in the Transvaal; the two species seem to be sharply separated geographically. Apart from the markings, the two may be distinguished from the fact that the toes are longer in *occidentalis*, the dorsal scales are not so sharply carinate as in *trivittata*, and the ear lobules are distinct.

Eaten by the Hottentots and called by them ! ! gt.

MABUIA VARIA (Pet.); B.M. Cat., III., 202.

Eldorado and Marandellas (O. A. Kidwell); Driekoppen, Hanover (A. Smith).

MABUIA STRIATA (Pet.); B.M. Cat., III., 204.

Marandellas (O. A. Kidwell); Francistown (R. M. Daniel); Immigrant (R. B. Eve); Mafeking (A. H. Wallis); Kyky, Nosob (L. W.); Kimberley (A. Kannemeyer, J. H. Power); Rooi Dam, Kimb. (G. Gain); Fort Richmond, Herbert (W. H. Wayland).

In open country they live amongst the stones, but are expert climbers, and when pursued will take to the thorn-trees with the confidence of squirrels. In the Kalahari they show a special attachment to the kameeldoornen (*Acacia giraffæ*). Near towns they have a preference for outhouses and human habitations.

MABUIA SULCATA (Pet.); B.M. Cat., III., 206.

Geluk, Gordonia (L. W.); Jacobsdal (J. H. Power); Kimberley (J. H. Power).

This species is common on the kopjes near Kimberley, living along with *Zonurus polyzonus* and *Agama atra*: we have never found it on the open veld. The Kimberley form is coal-black in the adult males, but only striped with black in the females and young. The three Gordonia specimens are olive-brown with the merest indication of dorsal striping; ventrally they are quite pale.

They are very active and alert, especially in the breeding season, September to November, when the male may be seen rapidly and incessantly bowing his head as he chases the female from rock to rock. The young, about four in number, are born four months afterwards;

they are all very conspicuously striped. At Kimberley during the comparatively mild winter of 1912 this species apparently did not hibernate.

LYGOSOMA SUNDEVALLI (Smith); B.M. Cat., III., 307.

Lake N'gami (J. G. Smith); Kyky (Miss Wilman).

The above specimens are both fragmentary, being the dried-up scraps used by the natives of German S.W. Africa and Bechuanaland as the much-prized antidote for snake-bite. The Bushman owners of these scraps parted with them with the greatest reluctance. Miss Wilman tried in vain to procure a whole specimen of the reptile from the European inhabitants of Gordonia, but it appeared that they had no actual knowledge of the living animal. It was believed to be very poisonous!

ABLEPHARUS WAHLBERGI (Smith); B.M. Cat., III., 350.

Eldorado (O. A. Kidwell).

SCELOTES BIPES (Linn.); B.M. Cat., III., 414.

Kalk Bay (J. A. Fogarty).

ACONTIAS MELEAGRIS (Linn.); B.M. Cat., III., 427.

Modder R. (J. H. Power); Oudtshoorn (J. L. Cairncross); Kalk Bay (J. H. Power).

TYPHLOSAURUS LINEATUS Boul.; B.M. Cat., III., 432.

Kyky (L. W.); Good Hope, Kimb. (A. Robinson).

This blind worm varies much in colour. Two of the Kyky specimens are entirely black dorsally, pale ventrally; two others are striped, but the stripes are fewer than those of typical examples and consist of rows of isolated dots. According to Mr. S. Blackbeard, they burrow with great rapidity, sinking in the ground "like lead through melted butter."

FAMILY CHAMÆLEONTIDÆ.

CHAMÆLEON QUILENSIS Boc.; B.M. Cat., III., 449.

Eldorado (O. A. Kidwell); Kyky (L. W.); Kimberley (A. Davis, G. Gain, Mrs. Hastings, J. H. Power).

This chameleon is exceptionally fond of locusts, and even the ill-smelling *Zonocerus elegans* is greedily devoured. It can run tolerably fast on the ground. The eggs, averaging thirty-five in number, are laid in deep holes excavated in the ground by the female who afterwards fills in the hole and levels the surface. Captive chameleons do not often survive the winter, but we have not observed any attempt to hibernate in the ground. This species is not known to occur south of Kimberley, but ranges almost throughout tropical Africa: in South Africa its home is open country with scattered bush.

Chamæleon dilepis Leach; B.M. Cat., III., 450.

Bushman Mine, N.W. Bech. Prot. (H. McLelland).

Chamæleon namaquensis Smith; B.M. Cat., III., 462.

Kimberley (Mrs. Hastings).

The above record probably represents an odd straggler, as this species is not otherwise known to us from Kimberley. In the lung characteristics it is related to *quilensis* rather than to the section so characteristic of the Cape (*pumilus*, *ventralis*, &c.).

Chamæleon pumilus Daud.; B.M. Cat., III., 458.

Somerset West (J. H. Power).

Chamæleon tæniobronchus Smith; B.M. Cat., III., 458.

East London (J. H. Power).

The specific characters of the *pumilus* group of chameleons are by no means sharply defined and we are not satisfied that the present separation into species correctly represents the facts. In the single specimen above recorded, the gular lobes are all small, being shortest and smallest in front and largest in the middle; they are all laterally compressed and covered with granules, those in the middle being a little broader than long, and the others subtriangular. There are 6 or 7 slightly enlarged tubercles more or less scattered along two rows on each side of the body; they are larger than any of the tubercles on the tail.

Part II.—**OPHIDIA.**

Family TYPHLOPIDÆ.

Typhlops bibroni (Smith); B.M. Cat., I., 44.

Johannesburg (Mrs. Hastings).

Typhlops mucroso (Pet.); B.M. Cat., I., 46.

Marandellas and Eldorado (O. A. Kidwell); Francistown (R. M. Daniel).

The latter example belongs to the variety *varius*.

TYPHLOPS DELALANDI Schleg.; B.M. Cat., I., 45.

Waldek's Plant (Mrs. Leighton); Barkly West (J. H. Power).

TYPHLOPS SCHINZI Boettg.; B.M. Cat., I., 47.

Lower Molopo (G. Lennox).

FAMILY GLAUCONIIDÆ.

GLAUCONIA SCUTIFRONS (Pet.); B.M. Cat., I., 68.

Good Hope, Kimb. (A. Robinson).

This species must be rare at Kimberley, if indeed it is actually indigenous there.

FAMILY BOIDÆ.

PYTHON SEBÆ (Gmel.); B.M. Cat., I., 86.

Okavango River (A. Wohlfarht); Baralong Farms (F. B. Parkinson); Forest Hill, S. Bech. Prot. (A. Siew); Mafeking (A. H. Wallis).

FAMILY COLUBRIDÆ.

A.—AGLYPHA.

ABLABOPHIS RUFULUS (Licht.); B.M. Cat., I., 318.

Somerset Strand (J. H. Power).

A very common water-snake, which seems to be absent from districts subject to periods of drought; it is unknown near Kimberley.

LAMPROPHIS AURORA (Linn.); B.M. Cat., I., 379.

Kenilworth, Kimb. (C. Jarvis, J. H. Power).

BOODON LINEATUS D. and B.; B.M. Cat., I., 332.

Marandellas (O. A. Kidwell); Francistown (R. M. Daniel); Madibi (F. B. Parkinson); Kuruman (B. Kelly, C. E. Wimble); Waldek's Plant (Mrs. Leighton); Kimberley (H. A. Black, A. L. Franceys, B. Green, Mrs. Helmore, W. Maltman, J. H. Power, W. D. Redpath, J. Swanson, C. E. Weston).

This is very common at Kimberley, being often found in outhouses or human habitations. A favourite prey of this snake is the common lizard, *Mabuia trivittata*. A specimen from Mossel Bay, slightly more than a yard in length, was found to contain a full-grown rat; but two juvenile examples which were kept for a night under a bell-jar along with a common mouse were devoured by the latter. In winter this snake may be found hibernating under stones or in the crevices of old wood. The eggs number from six to ten and vary somewhat in size in different clutches.

LYCOPHIDIUM CAPENSE (Smith); B.M. Cat., I., 339.

Marandellas (O. A. Kidwell).

SIMOCEPHALUS CAPENSIS (Smith); B.M. Cat., I., 345.

Mochudi (W. A. H. Harbor).

PSEUDASPIS CANA (Linn.); B.M. Cat., I., 382.

Moseley, Fauresmith (E. Heath); Kyky (L. W.); Rooidam, Kimb. (G. A. H. Gain); Kimberley (Miss O. McIntyre, J. H. Power, J. Truter, R. and L. Windell); Victoria West (P. D. Morris); Somerset Strand (J. H. Power).

CHLOROPHIS NATALENSIS (Smith); B.M. Cat., II., 94.

Middelburg, Transvaal (Mrs. Currey).

CHLOROPHIS HOPLOGASTER (Gunth.) (var.); B.M. Cat., II., 93.

Eldorado (O. A. Kidwell).

A single specimen which seems to connect *hoplogaster* with *emini* of Central Africa. A single anterior and posterior temporal; labials 4, 5, and 6 entering the eye; internasals about as long as prefrontals; preocular just in contact with the frontal on one side, separated therefrom on the other; 103 subcaudals.

PHILOTHAMNUS SEMIVARIEGATUS Smith; B.M. Cat., II., 99.

Eldorado (O. A. Kidwell); Francistown (R. M. Daniel); Vaal River Diggings (R. de Stadler); Barkly West (R. Mansfield, Y. Tournellec).

PROSYMNA SUNDEVALLI (Smith); B.M. Cat., II., 247.

Fort Richmond, Herbert (W. H. Wayland).

HOMALOSOMA LUTRIX (Linn.); B.M. Cat., II., 274.

Durban (N. Parkins); Kalk Bay (J. H. Power).

DASYPELTIS SCABRA (Linn.); B.M. Cat., II., 354.

Francistown (R. M. Daniel).

B.—OPISTHOGLYPHA.

TARBOPHIS SEMIANNULATUS (Smith); B.M. Cat., III., 51.

Zeerust (L. Cooper).

LEPTODIRA HOTAMBŒIA (Laurent.); B.M. Cat., III., 89.

Eldorado (O. A. Kidwell); Wirsing (W. L. Whiley); Colesberg (Donor?); Somerset Strand (J. H. Power).

This snake, according to the late J. M. Leslie, is a confirmed toad-eater; in the Transvaal it seems to prefer the red toad (*Bufo carens*) and it will also take *Breviceps mossambicus*.

AMPLORHINUS MULTIMACULATUS Smith; B.M. Cat., III., 125.

Somerset Strand (J. H. Power); Muizenberg (J. H. Power).

This snake is common near Somerset Strand. When taken in the hand it does not hesitate to bite, but according to our experience with no ill-effects. Nevertheless, when biting, it appears to deliberately chew with the poison fangs, as in the case of other *Opisthoglypha*. It seems to prefer a marshy habitat.

TRIMERORHINUS RHOMBEATUS (Linn.); B.M. Cat., III., 138.

Somerset Strand (J. H. Power).

TRIMERORHINUS TRITÆNIATUS (Günth.); B.M. Cat., III., 139.

Bembesi (Miss Nichol); Natal (J. E. Mackenzie); Kimberley (J. H. Power); Riet River (J. Watson).

RHAMPHIOPHIS MULTIMACULATUS (Smith); B.M. Cat., III., 148.

Kyky and Lower Molopo (L. W.).

PSAMMOPHIS NOTOSTICTUS Pet.; B.M. Cat., III., 156.

Driekoppen, Hanover (A. Smith); De Aar (J. Oberem).

PSAMMOPHIS FURCATUS Pet.; B.M. Cat., III., 164.

Madibi (F. B. Parkinson); Nosob and Springbok Vlei, Gordonia (L. W.); Moseley, Fauresmith (E. Heath); Kimberley (L. McBean, S. Cohen, P. O. Donnel, V. C. Ortlepp, J. H. Power, Miss Swanson, C. Tidmarsh).

This snake may sometimes be found in thorn-trees (*Acacia horrida*, &c.) near Kimberley. We once took a hibernating individual in an abandoned termite nest.

Psammophis subtæniatus Pet.; B.M. Cat., III., 160.

Francistown (R. M. Daniel).

This species seems to be the same as *P. bocagi* Boul., and *P. transvaalensis* Gough (see Records Albany Museum, II., 273).

Thelotornis kirtlandi (Hallow.); B.M. Cat., III., 185.

Eldorado (O. A. Kidwell); Francistown (R. M. Daniel, H. McLelland); Durban (N. Perkins).

Dispholidus typus (Smith); B.M. Cat., III., 187.

Francistown (R. M. Daniel); Vaal River Diggings (R. de Stadler); Kimberley (J. Swanson, T. Lee).

The Kimberley records relate to specimens that were introduced with fuel; otherwise we have not taken the species near Kimberley.

Aparallactus capensis Smith; B.M. Cat., III., 259.

Moseley, Fauresmith (E. Heath).

This snake is sometimes found in termite heaps.

C.—PROTEROGLYPHA.

Naia haie (Linn.); B.M. Cat., III., 374.

Marandellas (O. A. Kidwell); Francistown (R. M. Daniel); Mochudi (W. A. H. Harbor); Mosita (A. J. Keeley).

The colour variety *annulifera* occurs at Marandellas, Francistown, and Mosita, in each case along with the normal form apparently. We have only seen very limited material, and that in the form of skins; whether the banded form is merely of sexual significance, or a mendelian recessive, and to what extent the two forms are isolated we cannot say.

We are informed that the bands are very pronounced in young specimens.

This cobra is fond of fowls' eggs, which are swallowed whole and do not seem to be broken.

Naia flava (Merrem.); B.M. Cat., III., 376.

Riverton (P. T. Easton); Alexandersfontein, Kimb. (J. Nicholson); Secretaris, Kimb. (A. R. Radloff); Dronfield, Kimb. (R. F. Dott); Karreeboom, Kimb. (Mrs. Hill, Miss McIntyre); Kimberley (P. Stevens); Magersfontein, Kimb. (S. Bisset); Somerset Strand (J. H. Power).

This cobra has rather a varied diet. It will devour puff-adders and other snakes, and seems to have a special liking for frogs, including even the plathanda (*Xenopus lævis*).

NAIA NIGRICOLLIS Reinh.; B.M. Cat., III., 378.

Eldorado (O. A. Kidwell).

ASPIDELAPS SCUTATUS (Smith); B.M. Cat., III., 391.

Rooipoort, Kimb. (A. Pringle).

ELAPECHIS SUNDEVALLI (Smith); B.M. Cat., III., 360.

Kimberley (J. H. Power); Kimberley Mine, Kimb. (Donor ?).

The latter specimen is entirely black above and pale below, with no indication of banding; it is also abnormal in that the internasals are rather widely separated by the rostral. It has 165 ventrals.

ELAPECHIS GUENTHERI Boc.; B.M. Cat., III., 359.

Eldorado (O. A. Kidwell).

The specimen is juvenile, so that we are not absolutely certain of its specific identity.

HOMORELAPS LACTEUS (Linn.); B.M. Cat., III., 409.

Kamfersdam Mine, Kimb. (J. H. Power); Port Elizabeth (J. B. Harrison).

The Kimberley record probably represents an accidentally introduced specimen.

FAMILY VIPERIDÆ.

CAUSUS RHOMBEATUS (Licht.); B.M. Cat., III., 467.

Marandellas (O. A. Kidwell).

BITIS ARIETANS (Merrem.); B.M. Cat., III., 493.

Marandellas (O. A. Kidwell); Kyky and Nosob (L. W.); Kimberley (M. McIntyre, J. Orr, H. A. Bemiester); Magersfontein, Kimb. (J. H. Power).

BITIS CAUDALIS (Smith); B.M. Cat., III., 498.

Kyky (L. W.); Springbok Vlei (G. Lennox); Thornhill, Herbert (T. J. Cook).

Usually there are only 2 lower labials in contact with the enlarged chin shield, but in several examples there were 3.

Atractaspis rostrata Günth.; B.M. Cat., III., 514 (? = A. duerdeni Gough).

Genesa (J. Hill).

The specimen agrees in colour with Smith's figure of *bibroni* except that the head is not pale. The rostral shield has a sharper horizontal edge than in *bibroni*, and, moreover, the shape of the chin shields and of the third lower labial is in agreement with the figure given by Peters in the "Reise nach Mossambique" as *bibroni* (but referred to by Boulenger as *rostrata*). There are only 184 ventrals—but the specimen had been chopped in two, and possibly a portion had been lost.

A. duerdeni Gough (Records Albany Museum, II., 178) is based on a juvenile specimen, and the figure is considerably enlarged; the total length, not given in the original description, is 250 mm. The snout is rounded rather than prominent, and has no sharp horizontal edge; but such a character may not be the same in juveniles as in adults.

Note on the Phenomenon sometimes referred to as Mimicry or as Protective Colouration in Snakes.

Some remarkable instances of the similarity of colour pattern amongst snakes which are not genetically allied have been described by Dr. R. Sternfeld (Mit. a. d. Zool. Mus. Berlin, 1910, p. 58) in dealing with the ophidian fauna of German S.W. Africa. He points out that *Dasypeltis scabra*, *Rhamphiophis multimaculatus* and *Bitis caudalis*, which are all common in German S.W. Africa, have the same type of colouration, and inasmuch as the last mentioned is a poisonous viper, and the two former harmless, he believes it probable that this is a case of Batesian mimicry. As further support to this theory he states that in Upper Egypt, where *Bitis caudalis* does not occur, *Dasypeltis scabra* has another type of colour pattern, that of *Echis carinata*, which is also a viper.

In dealing with the Kalahari collection belonging to the Kimberley Museum, we also met with the same phenomenon. In the same localities along with *Bitis caudalis* there were found *Rhamphiophis multimaculatus* and the young of *Pseudaspis cana*, both of which, especially the former, have much the same colour and pattern—roughly speaking, dark blotches on a dull pale background—as *Bitis caudalis*.

Dasypeltis scabra, though absent from that collection, is common in certain parts of the Kalahari, and should be included in this so-called mimetic association: perhaps also we might add *Boodon guttatus* and *Typhlops schinzi*.

The mimicry explanation will of course imply that in past times the harmless snakes were very extensively eaten by birds or other foe which would not take vipers; but such discriminating foes are not known to occur to-day, and the secretary-bird, which is believed to prey largely on snakes, seems to include adders in its fare (see Stark and Sclater, "Birds of S. Africa"). To us it seems more reasonable to suppose that we are here dealing with protective colouration rather than mimicry—a supposition which also implies a ruthless destruction of snakes by their larger foes. Probably the simplest hypothesis is to regard this simple colour pattern as brought about in each case independently in direct response to the physical environment and not necessarily in adaptation therewith.

Part III.—BATRACHIA.

Family RANIDÆ.

Rana fuscigula (D. and B.); B.M. Cat., 50.

Benauwdheid's Font., Jacobsdal (C. F. S. Batten); Alexandersfontein, Kimberley (A. L. Franceys, J. B. Harrison, J. H. Power), Karreeboom, Kimb. (Miss M. McIntyre); Fort Richmond, Herbert (W. H. Wayland); Victoria West (P. D. Morris); Oudtshoorn (J. L. Cairncross); Kaaiman's River (Miss Wilman); Somerset Strand and Kalk Bay (J. H. Power).

This frog, near Kimberley, lives and breeds in dams where the water is frequently renewed, or in running streams: it is never found in muddy water. It is usually deep brown in colour, but may be even light green with darker spots; a pale vertebral line is occasionally present. Some eggs of this species, attached separately to water-weeds, were found in a dam on September 17th; they were transferred to an aquarium where the development was observed until the death of the tadpoles on October 15th, when the tadpoles were only 11 mm. long. Development seems to be comparatively slow, and most of the tadpoles appear to pass the winter as such: they usually reach a large size, a total length of 110 mm. being not unusual, whilst specimens of much larger proportions are occasionally met with. One monster was sent to us by Mr. P. D. Morris from Victoria West in May, 1910. The total length is 165 mm., the body is as large as that of a moderate-sized frog, the tail is thick and muscular, the limbs are well developed and the jaws and oral region are typically tadpole-like. In December, 1911, we observed this species in a stream near the summit of the mountain at Kalk Bay. Tadpoles and young in various stages of development were present, but the tadpoles were markedly different from those found at Kimberley, being considerably smaller and very fuscous. The total length of the Kalk Bay tadpoles was 42 mm. They were evidently undergoing a comparatively rapid metamorphosis.

Rana angolensis Boc.; B.M. Cat., 50.

Marandellas and Eldorado (O. A. Kidwell); Taungs (P. Court); Kuruman (C. S. Wimble); Modder River (J. H. Power); Kaaiman's River, George (Miss Wilman); East London (J. H. Power).

In localities near the boundary of the distribution area of *fuscigula* this species may sometimes be taken along with *fuscigula*. Father A. Hanisch, a few months ago, sent us a single specimen each of *angolensis* and *fuscigula* which were taken in the same pond at Ongeluk's Nek near Matatiele, Griqualand East. The two species were also taken together at Modder River in October, 1912.

Rana mascareniensis (D. and B.); B.M. Cat., 52.

Eldorado and Marandellas (O. A. Kidwell).

Rana oxyrhynchus (Smith); B.M. Cat., 51.

Marandellas (O. A. Kidwell).

Rana grayi (Smith); B.M. Cat., 53.

Oudtshoorn (Miss Wilman); Kaaiman's River, George (Miss S. Truter); Somerset Strand (J. H. Power); Kalk Bay (J. H. Power).

It lives in grassy places and apparently takes to water only for breeding purposes. The metamorphosis is probably not prolonged, for near Kalk Bay at the end of December, when frogs of all sizes were abundant on the hillsides, no tadpoles were to be seen.

Rana fasciata (Tschudi); B.M. Cat., 54.

Kalk Bay (J. H. Power).

Rana ruddi Boul., ?sp., P.Z.S., 1907, 480. Eldorado (O. A. Kidwell).

The single example, a female, agrees very closely in characteristic ornamentation and size with *ruddi* as described and figured by Mr. Boulenger. It differs in that the digits are a little longer, the feet are half-webbed, the snout is rather pointed and distinctly projecting, and the tarsometatarsal articulation appreciably surpasses the tip of the snout. The Eldorado species may prove to be the same as the Angola form *ornatissima* Boc., but whether *ornatissima* and *ruddi* are specifically distinct from *ornata* Pet. seems to us doubtful.

The specimen does not agree with the figure given by Bocage (Herpetologie d'Angola) for his *ornatissima* with regard to the pattern of its dorsal surface, in that respect being identical with *ruddi*.

Rana delalandi (Tschudi); B.M. Cat., 31.

Francistown (C. Butler); Madibi (F. B. Parkinson); Vryburg (H. C. de Beer); Kraai Pan (S. D. Smith); Taungs (P. Court); Kimberley (G. Gain, J. H. Power); Karreeboom, Kimb. (Mrs. McIntyre); Modder River (J. H. Power).

This frog is a nocturnal species which buries itself in the ground during daytime. In Kimberley at night-time it may be seen under the lamps catching beetles and moths. When burrowing it descends vent downwards, the body turning round and round as it shovels out the ground. When seized it has the objectionable habit of squirting water from the vent. Breeding may take place in the Kimberley neighbourhood any time between October and May, according to the rains; the frogs breed in temporary muddy pools. The males congregate at night-time on the edge of the pool and raise a series of sharp calls something like a quick ting, ting, ting, or tinga, tinga, tinga; the inflated gular pouch is blackish. The female is seized by the male and held in a strong embrace, the breeding pair occupying a hole in the ground at the side of the pool until the eggs are expelled, which takes place before sunrise. The eggs are laid separately and are attached to stones or plants, or sometimes a number are laid in or near the same spot forming a straggling mass. The egg measures about 1·5 mm. in diameter and its capsule 3 mm. The following notes relate to a metamorphosis we observed. Eggs laid November 19th morning: embryo 2 mm. long on the 20th: on the 21st 4 mm. long, wriggling inside the capsule: left the capsule on the 22nd, and became attached to the sides of the trough, external gills visible, total length 5·5 mm.: during the 22nd the external gills gradually disappeared: on the 23rd only a stump of the left gill now visible, the suckers had disappeared, total length 7 mm.: on November 24th the spiral gut distinct: on the 25th total length 10 mm., on the 27th 15 mm., the upper surfaces completely black, the abdomen spotted with gold: on December 5th total length 22 mm., the legs began to appear: on December 16th maximum length 34 mm. was reached, the head being 8·5 mm. broad: December 18th noticed movements of the fore-limbs, the legs measured 12 mm.: fore-limbs emerged on December 21st, usually the right limb first: on the 23rd the tail fin had almost disappeared: on December 25th the young frogs, about 12 mm. long, left the water.

Rana adspersa (Tschudi); B.M. Cat., 33.

Moseley, Fauresmith (E. Heath); Mafeking (A. H. Wallis); Madibi (F. B. Parkinson); Wirsing (W. L. Whiley); Kimberley (J. H. Power).

In the breeding season this species may often be seen in ponds and vleis, but at other times is of terrestrial habits, burrowing in the ground by day and emerging at night to feed. The breeding call of the male can be heard for several hundred yards, and reminds one of the lowing of a cow. The tadpoles develop rather slowly, but reach no great size: about 72 mm. seems to be the normal length of a full-sized tadpole. The tail is shorter but deeper than that of the *fuscigula* tadpole at Kimberley, the tail muscles being less developed and the myomeres fewer in number. They do not normally pass the winter in the tadpole stage. The young are ornamented dorsally with three bright yellow longitudinal streaks.

PHRYNOBATRACHUS NATALENSIS (Smith); B.M. Cat., p. 112.

Marandellas (O. A. Kidwell); Christiana (M. Moir).

CHIROMANTIS XERAMPELINA Pet.; B.M. Cat., 93.

Francistown (H. McLelland).

The breeding habits of this species are likely to prove interesting. According to information received from Mr. F. Streeter, of Hectorspruit, the course of events is much the same as in *C. rufescens* (see Gadow in "Camb. Nat. Hist. Amphibia and Reptiles" p. 244), but the female seems to exercise parental solicitude over her developing young: the case requires investigation.

RAPPIA UNDULATA Boul.; Ann. Mus. Congo, II., 1902, p. 4.

Marandellas (O. A. Kidwell).

In the present chaotic condition of the systematics of this genus, the above identification is only offered as a probability. The specimen was referred to as possibly *R. microps* in Records Albany Museum, II., 212.

RAPPIA NASUTA Gunth.; B.M. Cat., 127.

Marandellas (O. A. Kidwell).

We presume this is the same as *R. sugillata*, Cope.

RAPPIA MARMORATA (Rapp); B.M. Cat., 121.

Marandellas (O. A. Kidwell); Chisagwasha (F. Kolbe).

CASSINA SENEGALENSIS Gir.; B.M. Cat., 131.

Madibi (F. B. Parkinson); Kimberley (J. H. Power); Kaaiman's River (Miss Wilman).

The Kimberley record relates to a single specimen found dead in a well. It is a running frog and does not jump. Near Grahamstown, at midsummer, we have taken it in abandoned ant-hills near a vlei far remote from bush, but in general it seems to favour bush or forest districts, and is said to climb trees. Andrew Smith took his specimens in burrows in the ground.

Family ENGYSTOMATIDÆ.

Phrynomantis bifasciata (Smith); B.M. Cat., 172.

Eldorado and Marandellas (O. A. Kidwell); Madibi (F. B. Parkinson); Kraai Pan (S. D. Smith); Vryburg (H. C. de Beer and T. W. Heckes); Kimberley (R. C. Barrow).

The Kimberley specimens no doubt came in firewood from Bechuanaland: Smith's observation on the occurrence of this species within the internal cavities of trees furnishes the explanation.

Breviceps mossambicus Pet.; B.M. Cat., 177.

Eldorado and Marandellas (O. A. Kidwell); Kimberley (J. H. Power).

This species is not common at Kimberley. One specimen was found impaled through the head on a thorn-bush, evidently the victim of a shrike.

Sub-Family DYSCOPHINÆ.

Cacosternum böttgeri Boul., A.H.N.H. 5, XX., 51, and Records Albany Museum II., 215.

Madibi (F. B. Parkinson); Kimberley (J. H. Power); Oudtshoorn (J. L. Cairncross).

This tiny frog is extremely variable in its colours, which range from vivid greens to browns and reds; there may or may not be a yellow vertebral line and a similar one dorsolaterally, but blotches and spots of varying size are nearly always present though they may not be very definitely arranged. The various colours are all to be found in the same colony, and in captive specimens our experiments failed to bring any colour response by changing the colours of the environment. It is a terrestrial species of diurnal habits, and takes to water only at breeding-times, when it may be found in great numbers amongst the weeds or under the stones at the edge of shallow pools. During the dry season it remains hidden under stones in damp places or in the cracks of muddy ground. It can climb with ease over smooth vertical surfaces, such as a pane of glass, the belly being closely pressed against that surface. The breeding call is very characteristic, and resembles the sound made by the winding of a watch or by running the finger-nail over the teeth of a comb; the noise of a colony is quite deafening. The vocal sac of the male extends from the chin to the breast and is greatly inflated, being probably quite four times the size of the head. We have not observed the sexes in copula, but breeding males try to grasp each other round the neck, at the same time spinning round and round and making a clucking noise. The eggs are laid in masses of eight to twenty and are attached to plants. The following notes relate to the metamorphosis of larvæ kept in a small aquarium. Eggs laid on October 24th, the egg being about 1 mm. diameter: on the evening of next day tailed larvæ about 4 mm. long were wriggling inside the capsule: by evening of the 26th they left the capsule: 27th, external gills visible, but disappeared during the next 24 hours: 28th, morning, tiny stump of external gill on left side just visible, and same day the beating of the heart was observed: October 29th, the gut began to acquire a spiral coil and food was visible therein: October 31st, total length 8 mm.: November 4th, 11 mm., the colour being light brown above but dark below with golden spots: November 9th, total length, 15 mm., the hind legs just beginning to appear: November 11th, 17 mm. long: November 20th, 27 mm. long, the upper surfaces being bright green: November 25th, reached their maximum size, 31 mm., and rested at the bottom of the trough for several days, the upper surfaces spotted in patches with black and gold: November 26th, movements of fore-limbs visible, hind-limbs 12 mm. long; fore-limbs, the left one first, thrust out on the 28th: 29th, the tail fin almost entirely disappeared, the tail being 19 mm. long: November 30th, the tail only 4 mm. long and the body 10 mm., the little frogs left the water and took small flies. These young frogs showed very great diversity of colour. It should be mentioned that these notes apply only to the most advanced individuals of the little colony, for at various stages a number of the tadpoles lagged behind for some reason or other. We may note that the tadpoles of this frog and of *Rana delalandi* are often found closely associated together in the same parts of a pool: a dip of the net will at any time secure specimens of both species. According to all published accounts such an association is an exception. Mr. Boulenger mentions that *Rana temporaria* and *Bufo vulgaris* often breed in the same place, but the tadpoles always form distinct colonies (see "Tailless Batrachians of Europe").

Family BUFONIDÆ.

Bufo regularis Reuss; B.M. Cat., 298.

Eldorado (O. A. Kidwell); Francistown (R. M. Daniel); Madibi (F. B. Parkinson); Mafeking (A. H. Wallis); Genesa (J. Hill); Taungs

(B. and I. Sanderowitz); Kraai Pan (S. D. Smith); Kuruman (C. E., Wimble); Kimberley (J. H. Power); Modder River (J. H. Power); Oudtshoorn (Miss Wilman); Kaaiman's River (Miss S. Truter); Kalk Bay (J. H. Power).

The parotoid glands of this toad vary considerably in degree of development. In Kimberley examples they are wider and larger than in specimens from the Eastern Province; in Capetown examples they are broad and short. The granularity of the belly also varies, being less pronounced in the Kimberley examples than in those from Marandellas. The tympanum varies in size; a very hispid example from Kraai Pan has the tympanum on one side quite twice the size of its fellow.

At Modder River the breeding season commences about the end of September or beginning of October, when the males resort to little pools amongst the rocks, and during night-time make loud and incessant calls to attract the females; the vocal sac, bluish in colour, becomes inflated to about twice the size of the head. The male call resembles the hoarse "waak-waak" of duck, and the female responds with a call like "waap," followed by a quick "wap, wap." Though the males far exceed the females in number, they seem to rely on their vocal talents to attract the females, and do not actually move in search of partners. The responding call of the female causes the male to strain his vocal organ to the utmost, and at such time he will continue to call even in the immediate proximity of a human observer armed with a lamp. The breeding pair crawl about in shallow water during the night and the following day when the eggs are laid. The eggs are crowded together in a long string of jelly of uniform thickness, which the parents wind between stones and water-plants in no regular order. One female was observed to lay a string of eggs eight yards long, and probably had not then exhausted the store; the jelly was about 5 mm. in diameter and the eggs 1·5 mm. diameter, whilst the number of eggs contained in a length of one foot was counted as 253.

Bufo angusticeps Smith; B.M. Cat., 300.

Muizenberg (J. H. Power).

Bufo carens Smith; B.M. Cat., 301.

Eldorado (O. A. Kidwell); Wirsing (W. L. Whiley); Taungs (P. Court, B. and I. Senderowitz); Kimberley (H. Phear).

Bufo vertebralis Smith; Zoology of South Africa, Reptiles, Pl. 68, and P.Z.S., 1905, 2. 250.

Madibi (F. B. Parkinson); Kimberley (J. H. Power).

This small toad is of diurnal habits and breeds in small stagnant and very muddy pools, both in and around Kimberley. A colony may be heard during the daytime at a distance of a mile or more, the noise, which might be confused with that of the locust *Xiphocera canescens*, reminding one of castanets. The breeding male has a bright yellow throat. The eggs are exuded in a long string, looking much like a string of beads, and during this process the breeding pair swim about winding the string of eggs around plants or stones. The eggs are appreciably larger than those of *B. regularis*. The following notes relate to the metamorphosis as observed by one of us. Eggs laid on February 4th morning: by evening, February 5th, the embryo was 3 mm. long: on the morning of the 6th the tail fin had appeared: the following morning the tadpoles 6·5 mm. long, provided with external gills, were found clinging to the egg capsule and to the sides of the trough: next day, February 8th, the external gills had disappeared and the gut showed its first coil: by February 10th the rudiments of hind-limbs were visible in the shape of minute white buds: on the morning of the 11th the total length was 14 mm., and the upper surface of the body was dark brown or grey with numerous gold spots extending along the sides of the body and the upper half of the tail: by February 14th the legs had reached a length of about 2 mm.: on the 15th they reached their maximum length, measuring altogether 17 mm.: on February 17th the movements of the fore-limbs were distinctly visible, and by this time the tadpole had acquired the characteristic whitish spot found on the dorsal surface of the body in this species: the tadpoles remained quiet at the bottom of the tank, the abdomen began to shrink, and on the 19th the arms were thrust out: on February 20th the tiny toads, measuring only 6 mm. to 8 mm., exclusive of the fast-disappearing tail, began to leave the water.

This is a very rapid metamorphosis, the whole process being completed in 16 days.

BUFO GARIEPENSIS Smith (= *B. granti*, Boul.); A.M.N.H. (7), XII., 215, and Records Albany Museum, II., 281.

Upington (Miss H. Lennox); Modder River (J. H. Power); Oudtshoorn (J. L. Cairncross); Kaaiman's River (Miss Wilman).

We are informed that this is a running toad and does not jump. The Modder River example was captured at night along with 4 or 5 specimens of *regularis*.

FAMILY PIPIDÆ.

XENOPUS LÆVIS (Daud.); B.M. Cat., 456.

Benauwdheids Fontein, Kimb. (C. Batten); Alexandersfontein, Kimb. (A. L. Franceys, J. H. Power).

The records for this species have not been inserted, as it has been received from all parts of South Africa except the Kalahari Desert.

This is the most widely distributed and most aquatic of the South African batrachians. It ordinarily lives in stagnant pools, in wells and vleis where no other frog is to be seen. According to Dr. Rattray it can tolerate brackish water and often breeds therein. When handled it becomes covered with a very ill-smelling foamy lather which emanates from the pores of the skin whilst liquid is also exuded from the vent and spreads over the body. This, or some other secretion, seems to be very poisonous: a *Rana fuscigula* which happened to be placed in the same bottle with a *Xenopus* was found to be quite dead fifteen minutes afterwards, though the *Xenopus* seemed unaffected, whilst both were covered with a glutinous white foam which also lined the sides of the bottle. Its occurrence in numerous isolated ponds seems explicable only on the supposition that this species habitually migrates; most observers agree that such is the case, but we have never actually witnessed a migration, which, however, may be usually a nocturnal function. Mr. Gunning, of Kimberley, informs us that one fine evening some years ago he saw a large procession of this species, comprising some thousands of individuals, on the march towards a river away from a dam which was just commencing to dry up. The dams frequented by *Xenopus* may completely dry up in winter, and examination of the site has revealed no buried toads and no hibernating individuals except for one or two juveniles which were hidden under stones or in other damp places. Nevertheless these toads often spend the winter in the liquid mud of shallow ponds, and must occasionally run the risk of becoming entombed under baked mud. That they may sometimes be thus entombed without fatal results is indicated by some facts related to us by Mr. Stoney, of Alexandersfontein. The duckpond at Alexandersfontein was cleared out in July, 1910, when the toads were probably in a torpid condition, and the mud was spread over the adjacent lawns and grounds forming an extensive layer varying in thickness from an inch to a foot. A month later, when the first spring rains appeared, *Xenopus lævis* arose in great numbers from the mud and trekked in all directions, invading the houses and blocking up the irrigation pipes, many of them perishing in the heat of the sun. It is interesting to note that they wandered aimlessly in various directions, in spite of the fact that the newly filled duckpond was only twenty or thirty yards away. In damp mud this toad can live for a long time without food: a few young specimens which were kept in a biscuit tin along with some lumps of mud remained there in good condition for eight months.

The colour is normally almost black with or without irregular small spots, but the intensity of the colour varies much according to external conditions. As an experiment, a few dark specimens were kept in a white enamelled trough open at the top, but after a fortnight there was no appreciable colour change: on covering them with a sheet of white paper the toads turned yellow within twenty-four hours. This obviously suggests that the afferent impulses of the reflex are visual, the eyes being situated on the top of the head.

NOTE ON DOUBLE ALTERNANTS.

By Thomas Muir, LL.D., F.R.S.

(Read October 16, 1912.)

1. The first form of alternant to which it is desired to direct attention is the particular case of

$$\left|(\alpha_1+\beta_1)^p(\alpha_2+\beta_2)^p\ldots(\alpha_n+\beta_n)^p\right|, \qquad \text{or } \mathrm{D}_{n;p} \text{ say,}$$

where $p=n$, the case where $p=n-1$ having been already dealt with by Zehfuss (*Zeitschrift f. Math. u. Phys.* iv. pp. 233–236). The problem is, of course, to find the quotient resulting from dividing $\mathrm{D}_{n;n}$ by the difference-product of the α's and the difference-product of the β's—that is to say, the quotient

$$\mathrm{D}_{n;n} \div \zeta^{\frac{1}{2}}(\alpha_1, \alpha_2, \ldots, \alpha_n) \,.\, \zeta^{\frac{1}{2}}(\beta_1, \beta_2, \ldots, \beta_n),$$

or say

$$\mathrm{D}_{n;n} \div \zeta_1^{\frac{1}{2}}\zeta_2^{\frac{1}{2}}.$$

2. It is readily seen that by row-by-row multiplication we have

$$\begin{vmatrix} \alpha_1^3 & 3\alpha_1^2 & 3\alpha_1 & 1 \\ \alpha_2^3 & 3\alpha_2^2 & 3\alpha_2 & 1 \\ \alpha_3^3 & 3\alpha_3^2 & 3\alpha_3 & 1 \\ -\beta_1\beta_2\beta_3 & \Sigma\beta_1\beta_2 & -\Sigma\beta_1 & 1 \end{vmatrix} \cdot \begin{vmatrix} 1 & \beta_1 & \beta_1^2 & \beta_1^3 \\ 1 & \beta_2 & \beta_2^2 & \beta_2^3 \\ 1 & \beta_3 & \beta_3^2 & \beta_3^3 \\ 1 & x & x^2 & x^3 \end{vmatrix}$$

$$= \begin{vmatrix} (\alpha_1+\beta_1)^3 & (\alpha_1+\beta_2)^3 & (\alpha_1+\beta_3)^3 & (\alpha_1+x)^3 \\ (\alpha_2+\beta_1)^3 & (\alpha_2+\beta_2)^3 & (\alpha_2+\beta_3)^3 & (\alpha_2+x)^3 \\ (\alpha_3+\beta_1)^3 & (\alpha_3+\beta_2)^3 & (\alpha_3+\beta_3)^3 & (\alpha_3+x)^3 \\ \cdot & \cdot & \cdot & (x-\beta_1)(x-\beta_2)(x-\beta_3) \end{vmatrix},$$

and that on dividing both sides of this by $(x-\beta_1)(x-\beta_2)(x-\beta_3)$ there results

$$\mathrm{D}_{3;3} = \begin{vmatrix} \alpha_1^3 & 3\alpha_1^2 & 3\alpha_1 & 1 \\ \alpha_2^3 & 3\alpha_2^2 & 3\alpha_2 & 1 \\ \alpha_3^3 & 3\alpha_3^2 & 3\alpha_3 & 1 \\ -\beta_1\beta_2\beta_3 & \Sigma\beta_1\beta_2 & -\Sigma\beta_1 & 1 \end{vmatrix} \zeta^{\frac{1}{2}}(\beta_1, \beta_2, \beta_3).$$

But the four-line determinant here is seen to be divisible by $\alpha_3 - \alpha_2$, $\alpha_3 - \alpha_1$, $\alpha_2 - \alpha_1$; and, these factors being removed in the ordinary way, we have

$$D_{3;3} = \begin{vmatrix} \alpha_1^3 & 3\alpha_1^2 & 3\alpha_1 & 1 \\ \alpha_2^2 + \alpha_2\alpha_1 + \alpha_1^2 & 3(\alpha_1 + \alpha_2) & 3 & \cdot \\ \alpha_3 + \alpha_2 + \alpha_1 & 3 & \cdot & \cdot \\ -\beta_1\beta_2\beta_3 & \Sigma\beta_1\beta_2 & -\Sigma\beta_1 & 1 \end{vmatrix} \zeta_2^{\frac{1}{2}}\zeta_1^{\frac{1}{2}}.$$

Further simplification is effected by performing the operations

$$\begin{aligned} \text{row}_1 - \alpha_1.\text{row}_2 + \alpha_1\alpha_2.\text{row}_3, \\ \text{row}_2 - (\alpha_1 + \alpha_2).\text{row}_3, \end{aligned}$$

the penultimate and final results being

$$\frac{D_{3:3}}{\zeta_1^{\frac{1}{2}}\zeta_2^{\frac{1}{2}}} = \begin{vmatrix} \alpha_1\alpha_2\alpha_3 & \cdot & \cdot & 1 \\ -\Sigma\alpha_1\alpha_2 & \cdot & 3 & \cdot \\ \Sigma\alpha_1 & 3 & \cdot & \cdot \\ -\beta_1\beta_2\beta_3 & \Sigma\beta_1\beta_2 & -\Sigma\beta_1 & 1 \end{vmatrix},$$

$$= \begin{vmatrix} \alpha_1\alpha_2\alpha_3 + \beta_1\beta_2\beta_3 & \Sigma\beta_1\beta_2 & \Sigma\beta_1 \\ \Sigma\alpha_1\alpha_2 & \cdot & -3 \\ \Sigma\alpha_1 & -3 & \cdot \end{vmatrix}.$$

Proceeding in exactly similar fashion we obtain

$$\frac{D_{4;4}}{\zeta_1^{\frac{1}{2}}\zeta_2^{\frac{1}{2}}} = \begin{vmatrix} \alpha_1\alpha_2\alpha_3\alpha_4 + \beta_1\beta_2\beta_3\beta_4 & \Sigma\beta_1\beta_2\beta_3 & \Sigma\beta_1\beta_2 & \Sigma\beta_1 \\ \Sigma\alpha_1\alpha_2\alpha_3 & \cdot & \cdot & -4 \\ \Sigma\alpha_1\alpha_2 & \cdot & -6 & \cdot \\ \Sigma\alpha_1 & -4 & \cdot & \cdot \end{vmatrix}$$

and so on, generally. (I.)

3. The form of quotient obtained is manifestly invariant (1) to the interchange of any two α's, (2) to the interchange of any two β's, and (3) to the simultaneous interchange of every α with the corresponding β; and this, as we know, is what ought to be.

4. On account of the number of zero elements in the quotient, it is possible to put it in a simple non-determinant form: thus

$$D_{2;2} \div \zeta_1^{\frac{1}{2}}\zeta_2^{\frac{1}{2}} = -2(\alpha_1\alpha_2 + \beta_1\beta_2) - \Sigma\alpha_1.\Sigma\beta_1,$$

$$D_{3;3} \div \zeta_1^{\frac{1}{2}}\zeta_2^{\frac{1}{2}} = -3.3(\alpha_1\alpha_2\alpha_3 + \beta_1\beta_2\beta_3) - 3(\Sigma\alpha_1\alpha_2.\Sigma\beta_1 + \Sigma\alpha_1.\Sigma\beta_1\beta_2),$$

....

or, still more interestingly as regards the right-hand members,

$$-1.2.1\left\{\alpha_1\alpha_2+\ \tfrac{1}{2}\Sigma\alpha_1.\Sigma\beta_1+\beta_1\beta_2\right\},$$
$$-1.3.3.1\left\{\alpha_1\alpha_2\alpha_3+\tfrac{1}{3}\Sigma\alpha_1\alpha_2.\Sigma\beta_1+\tfrac{1}{3}\Sigma\alpha_1.\Sigma\beta_1\beta_2+\beta_1\beta_2\beta_3\right\},$$
$$+1.4.6.4.1\left\{\alpha_1\alpha_2\alpha_3\alpha_4+\tfrac{1}{4}\Sigma\alpha_1\alpha_2\alpha_3.\Sigma\beta_1+\tfrac{1}{6}\Sigma\alpha_1\alpha_2.\Sigma\beta_1\beta_2+\tfrac{1}{4}\Sigma\alpha_1.\Sigma\beta_1\beta_2\beta_3+\beta_1\beta_2\beta_3\beta_4\right\},$$

....

Further, we observe that the determinant quotients are unisignant, the common sign being + when n is of the form $4m$ or $4m+1$, and − when of the form $4m+2$ or $4m+3$. (II.)

5. An interesting verificatory proof is reached by taking the asserted result and multiplying it row-wise by $\zeta_2^{\frac{1}{2}}$, and thereafter multiplying the product column-wise by $\zeta_1^{\frac{1}{2}}$. Thus, if we multiply

$$\left|\begin{array}{ccccc} \alpha_1\alpha_2\alpha_3\alpha_4\alpha_5+\beta_1\beta_2\beta_3\beta_4\beta_5 & \Sigma\beta_1\beta_2\beta_3\beta_4 & \Sigma\beta_1\beta_2\beta_3 & \Sigma\beta_1\beta_2 & \Sigma\beta_1 \\ \Sigma\alpha_1\alpha_2\alpha_3\alpha_4 & . & . & . & -5 \\ \Sigma\alpha_1\alpha_2\alpha_3 & . & . & -10 & . \\ \Sigma\alpha_1\alpha_2 & . & -10 & . & . \\ \Sigma\alpha_1 & -5 & . & . & . \end{array}\right|$$

row-wise by $\zeta_2^{\frac{1}{2}}$ in the form

$$\left|\begin{array}{ccccc} 1 & -\beta_1 & \beta_1^2 & -\beta_1^3 & \beta_1^4 \\ 1 & -\beta_2 & \beta_2^2 & -\beta_2^3 & \beta_2^4 \\ 1 & -\beta_3 & \beta_3^2 & -\beta_3^3 & \beta_3^4 \\ 1 & -\beta_4 & \beta_4^2 & -\beta_4^3 & \beta_4^4 \\ 1 & -\beta_5 & \beta_5^2 & -\beta_5^3 & \beta_5^4 \end{array}\right|$$

we obtain

$$\left|\begin{array}{ccc} \alpha_1\alpha_2\alpha_3\alpha_4\alpha_5+\beta_1^5 & \cdots & \alpha_1\alpha_2\alpha_3\alpha_4\alpha_5+\beta_5^5 \\ \Sigma\alpha_1\alpha_2\alpha_3\alpha_4-5\beta_1^4 & \cdots & \Sigma\alpha_1\alpha_2\alpha_3\alpha_4-5\beta_5^4 \\ \Sigma\alpha_1\alpha_2\alpha_3+10\beta_1^3 & \cdots & \Sigma\alpha_1\alpha_2\alpha_3+10\beta_5^3 \\ \Sigma\alpha_1\alpha_2-10\beta_1^2 & \cdots & \Sigma\alpha_1\alpha_2-10\beta_5^2 \\ \Sigma\alpha_1+5\beta_1 & \cdots & \Sigma\alpha_1+5\beta_5 \end{array}\right|,$$

and the multiplication of this column-wise by $\zeta_1^{\frac{1}{2}}$ in the form

$$\left|\begin{array}{ccccc} 1 & 1 & 1 & 1 & 1 \\ -\alpha_1 & -\alpha_2 & -\alpha_3 & -\alpha_4 & -\alpha_5 \\ \alpha_1^2 & \alpha_2^2 & \alpha_3^2 & \alpha_4^2 & \alpha_5^2 \\ -\alpha_1^3 & -\alpha_2^3 & -\alpha_3^3 & -\alpha_4^3 & -\alpha_5^3 \\ \alpha_1^4 & \alpha_2^4 & \alpha_3^4 & \alpha_4^4 & \alpha_5^4 \end{array}\right|$$

produces

$$\begin{vmatrix} (\alpha_1+\beta_1)^5 & \cdots & (\alpha_1+\beta_5)^5 \\ \cdots\cdots & \cdots\cdots & \cdots\cdots \\ (\alpha_5+\beta_1)^5 & \cdots & (\alpha_5+\beta_5)^5 \end{vmatrix} . \qquad \text{(III.)}$$

6. Taking these results along with Scott's of 1879 (*Messenger of Math.* viii. pp. 182–187), we obtain a remarkable identity—possibly the first observed of its kind—giving an expression for a determinant in terms of a permanent, that is to say, a function of one class in terms of another of the directly opposite class. Thus, for the fourth order, we have

$$\begin{vmatrix} \alpha_1\alpha_2\alpha_3\alpha_4+\beta_1\beta_2\beta_3\beta_4 & \Sigma\beta_1\beta_2\beta_3 & \Sigma\beta_1\beta_2 & \Sigma\beta_1 \\ \Sigma\alpha_1\alpha_2\alpha_3 & . & . & -4 \\ \Sigma\alpha_1\alpha_2 & . & -6 & . \\ \Sigma\alpha_1 & -4 & . & . \end{vmatrix} = 4 \overset{+\qquad\qquad\qquad\qquad +}{\begin{vmatrix} \alpha_1+\beta_1 & \cdots & \alpha_1+\beta_4 \\ \alpha_2+\beta_1 & \cdots & \alpha_2+\beta_4 \\ \alpha_3+\beta_1 & \cdots & \alpha_3+\beta_4 \\ \alpha_4+\beta_1 & \cdots & \alpha_4+\beta_4 \end{vmatrix}}$$

the connecting factor, which is here 4, being for the nth order

$$(-1)^{\frac{1}{2}n(n-1)} \cdot \frac{n_1 n_2 \ldots n_n}{1.2 \ldots n}$$

where $n_r = n(n-1) \ldots (n-r+1)/1.2 \ldots r.$ (IV.)

7. A direct mode of establishing this identity is something to be desired. All that we can suggest as a substitute is a proof that the two members of it have the same final development. Taking, for example, the permanent of the third order

$$\overset{+\qquad\qquad\qquad\qquad\qquad +}{\begin{vmatrix} \alpha_1+\beta_1 & \alpha_1+\beta_2 & \alpha_1+\beta_3 \\ \alpha_2+\beta_1 & \alpha_2+\beta_2 & \alpha_2+\beta_3 \\ \alpha_3+\beta_1 & \alpha_3+\beta_2 & \alpha_3+\beta_3 \end{vmatrix}}$$

and recalling the fact that the law for the partitionment of determinants with polynomial elements holds also for permanents we obtain

$$\overset{+\qquad\qquad +}{\begin{vmatrix} \alpha_1 & \alpha_1 & \alpha_1 \\ \alpha_2 & \alpha_2 & \alpha_2 \\ \alpha_3 & \alpha_3 & \alpha_3 \end{vmatrix}} + \overset{+\qquad\qquad +}{\begin{vmatrix} \alpha_1 & \alpha_1 & \beta_3 \\ \alpha_2 & \alpha_2 & \beta_3 \\ \alpha_3 & \alpha_3 & \beta_3 \end{vmatrix}} + \ldots\ldots + \overset{+\qquad\qquad +}{\begin{vmatrix} \beta_1 & \beta_2 & \beta_3 \\ \beta_1 & \beta_2 & \beta_3 \\ \beta_1 & \beta_2 & \beta_3 \end{vmatrix}}$$

which (*Educ. Times*, lxv. p. 139)

$$= 6\alpha_1\alpha_2\alpha_3 + 2\Sigma\alpha_1\alpha_2.\beta_3 + 2\Sigma\alpha_1\alpha_2.\beta_2 + 2\Sigma\alpha_1\alpha_2.\beta_1 + 2\Sigma\alpha_1.\beta_2\beta_3 + 2\Sigma\alpha_1.\beta_1\beta_3 + 2\Sigma\alpha_1.\beta_1\beta_2 + 6\beta_1\beta_2\beta_3,$$

$$= 6\alpha_1\alpha_2\alpha_3 + 2\Sigma\alpha_1\alpha_2.\Sigma\beta_1 + 2\Sigma\alpha_1.\Sigma\beta_1\beta_2 + 6\beta_1\beta_2\beta_3,$$

$$= -\tfrac{2}{3}\begin{vmatrix} \alpha_1\alpha_2\alpha_3+\beta_1\beta_2\beta_3 & \Sigma\beta_1\beta_2 & \Sigma\beta_1 \\ \Sigma\alpha_1\alpha_2 & \cdot & -3 \\ \Sigma\alpha_1 & -3 & \cdot \end{vmatrix}. \qquad \text{(V.)}$$

8. Turning now to alternants of the form $D_{n;n+1}$ let us consider first $D_{2;3}$. By the multiplication-theorem there is obtained

$$\begin{vmatrix} \alpha_1^3 & 3\alpha_1^2 & 3\alpha_1 & 1 \\ \alpha_2^3 & 3\alpha_2^2 & 3\alpha_2 & 1 \\ \beta_1\beta_2 & -\Sigma\beta_1 & 1 & \cdot \\ \cdot & \beta_1\beta_2 & -\Sigma\beta_1 & 1 \end{vmatrix} \cdot \begin{vmatrix} 1 & \beta_1 & \beta_1^2 & \beta_1^3 \\ 1 & \beta_2 & \beta_2^2 & \beta_2^3 \\ 1 & x & x^2 & x^3 \\ 1 & y & y^2 & y^3 \end{vmatrix}$$

$$= \begin{vmatrix} (\alpha_1+\beta_1)^3 & (\alpha_1+\beta_2)^3 & (\alpha_1+x)^3 & (\alpha_1+y)^3 \\ (\alpha_2+\beta_1)^3 & (\alpha_2+\beta_2)^3 & (\alpha_2+x)^3 & (\alpha_2+y)^3 \\ \cdot & \cdot & (x-\beta_1)(x-\beta_2) & (y-\beta_1)(y-\beta_2) \\ \cdot & \cdot & x(x-\beta_1(x-\beta_2) & y(y-\beta_1)(y-\beta_2) \end{vmatrix},$$

the division of both members of which by

$$(y-x)\,.\,(y-\beta_2)(y-\beta_1)\,.\,(x-\beta_2)(x-\beta_1)$$

gives

$$D_{2;3} = \begin{vmatrix} \alpha_1^3 & 3\alpha_1^2 & 3\alpha_1 & 1 \\ \alpha_2^3 & 3\alpha_2^2 & 3\alpha_2 & 1 \\ \beta_1\beta_2 & -\Sigma\beta_1 & 1 & \cdot \\ \cdot & \beta_1\beta_2 & -\Sigma\beta_1 & 1 \end{vmatrix} \zeta^{\frac{1}{2}}(\beta_1, \beta_2).$$

The four-line determinant here, however, contains the factor $\alpha_2-\alpha_1$, which being removed and a self-evident simplification effected, we have for the remaining determinant

$$\begin{vmatrix} -\alpha_1\alpha_2\,.\,\Sigma\alpha_1 & -3\alpha_1\alpha_2 & \cdot & 1 \\ \alpha_2^2+\alpha_2\alpha_1+\alpha_1^2 & 3\Sigma\alpha_1 & 3 & \cdot \\ \beta_1\beta_2 & -\Sigma\beta_1 & 1 & \cdot \\ \cdot & \beta_1\beta_2 & -\Sigma\beta_1 & 1 \end{vmatrix},$$

and by performing on this the operations

$$\text{col}_4 \times \alpha_1\alpha_2, \quad \text{row}_4 \div \alpha_1\alpha_2, \quad \text{row}_2 + \Sigma\alpha_1.\text{row}_1$$

in succession it is transformed into

$$\begin{vmatrix} -\Sigma\alpha_1 & -3 & \cdot & \cdot \\ -\alpha_1\alpha_2 & \cdot & 3 & \Sigma\alpha_1 \\ \beta_1\beta_2 & -\Sigma\beta_1 & 1 & \cdot \\ \cdot & \beta_1\beta_2 & -\Sigma\beta_1 & \alpha_1\alpha_2 \end{vmatrix}.$$

We thus have finally

$$\frac{D_{2;3}}{\zeta_1^{\frac{1}{2}}\zeta_2^{\frac{1}{2}}} = -\begin{vmatrix} \beta_1\beta_2 & -\Sigma\beta_1 & 1 & \cdot \\ -\Sigma\alpha_1 & -3 & \cdot & 1 \\ \alpha_1\alpha_2 & \cdot & -3 & -\Sigma\alpha_1 \\ \cdot & \beta_1\beta_2 & -\Sigma\beta_1 & \alpha_1\alpha_2 \end{vmatrix},$$

where, be it noted, any two elements situated symmetrically with respect to the secondary diagonal do not differ in form, the one being the same symmetric function of the one set of variables as the other is of the other. As a consequence the invariance referred to in §3 holds here also, as it ought.

In exactly similar fashion there is obtained

$$\frac{D_{3;4}}{\zeta_1^{\frac{1}{2}}\zeta_2^{\frac{1}{2}}} = -\begin{vmatrix} -\beta_1\beta_2\beta_3 & \Sigma\beta_1\beta_2 & -\Sigma\beta_1 & 1 & \cdot \\ \Sigma\alpha_1 & 4 & \cdot & \cdot & 1 \\ -\Sigma\alpha_1\alpha_2 & \cdot & 6 & \cdot & -\Sigma\alpha_1 \\ \alpha_1\alpha_2\alpha_3 & \cdot & \cdot & 4 & \Sigma\alpha_1\alpha_2 \\ \cdot & \beta_1\beta_2\beta_3 & -\Sigma\beta_1\beta_2 & \Sigma\beta_1 & -\alpha_1\alpha_2\alpha_3 \end{vmatrix},$$

and so, generally. (VI.)

9. Doubtless a verificatory proof of this result, similar to that of §7, could be devised; and as a matter of fact in the case of $-D_{2;3} \div \zeta_1^{\frac{1}{2}}\zeta_2^{\frac{1}{2}}$ we have only got to multiply row-wise the asserted equivalent by $-(\beta_2-\beta_1)$ in the form

$$\begin{vmatrix} 1 & \beta_1 & \beta_1^2 & \cdot \\ 1 & \beta_2 & \beta_2^2 & \cdot \\ \cdot & \cdot & \cdot & 1 \\ \cdot & \cdot & 1 & \cdot \end{vmatrix}$$

and then multiply column-wise the product so reached by $-\alpha_1\alpha_2(\alpha_2-\alpha_1)$ in the form

$$\begin{vmatrix} \alpha_1^2 & \alpha_2^2 & \cdot \\ \alpha_1 & \alpha_2 & \cdot \\ 1 & 1 & 1 \end{vmatrix}.$$

10. In the third place let us look at alternants of the form $D_{n;\,n+2}$, taking only the simplest case. By proceeding on lines closely analogous to the above, we readily find

$$D_{2;\,4} = \begin{vmatrix} \alpha_1^4 & 4\alpha_1^3 & 6\alpha_1^2 & 4\alpha_1 & 1 \\ \alpha_2^4 & 4\alpha_2^3 & 6\alpha_2^2 & 4\alpha_2 & 1 \\ \beta_1\beta_2 & -\Sigma\beta_1 & 1 & \cdot & \cdot \\ \cdot & \beta_1\beta_2 & -\Sigma\beta_1 & 1 & \cdot \\ \cdot & \cdot & \beta_1\beta_2 & -\Sigma\beta_1 & 1 \end{vmatrix} \zeta_2^{\frac{1}{2}}.$$

and at a farther stage

$$D_{2;\,4} = \begin{vmatrix} -(\alpha_1^2+\alpha_1\alpha_2+\alpha_2^2) & -4\Sigma\alpha_1 & -6 & \cdot & 1 \\ -\alpha_1\alpha_2(\alpha_1+\alpha_2) & -4\alpha_1\alpha_2 & \cdot & 4 & \Sigma\alpha_1 \\ \beta_1\beta_2 & -\Sigma\beta_1 & 1 & \cdot & \cdot \\ \cdot & \beta_1\beta_2 & -\Sigma\beta_1 & 1 & \cdot \\ \cdot & \cdot & \beta_1\beta_2 & -\Sigma\beta_1 & \alpha_1\alpha_2 \end{vmatrix} \zeta_1^{\frac{1}{2}}\zeta_2^{\frac{1}{2}}$$

A column of 0's is then appended and the additional row

$$\Sigma\alpha_1 \quad 4 \quad \cdot \quad \cdot \quad \cdot \quad 1$$

prefixed, with the result that our next simplification brings us to

$$\frac{D_{2;\,4}}{\zeta_1^{\frac{1}{2}}\zeta_2^{\frac{1}{2}}} = -\begin{vmatrix} -\Sigma\alpha_1 & 1 & \cdot & -4 & \cdot & \cdot \\ \alpha_1\alpha_2 & -\Sigma\alpha_1 & 1 & \cdot & -6 & \cdot \\ \cdot & \alpha_1\alpha_2 & -\Sigma\alpha_1 & \cdot & \cdot & -4 \\ \beta_1\beta_2 & \cdot & \cdot & -\Sigma\beta_1 & 1 & \cdot \\ \cdot & \cdot & \cdot & \beta_1\beta_2 & -\Sigma\beta_1 & 1 \\ \cdot & \cdot & \alpha_1\alpha_3 & \cdot & \beta_1\beta_2 & -\Sigma\beta_1 \end{vmatrix}, \qquad \text{(VII.)}$$

a result which again satisfies the tests regarding invariance.

11. A general theorem in regard to $D_{n;\,n+h}$ in agreement with Garbieri's of 1878 (*Giornale di Mat.* xvi. pp. 1–17) is thus foreshadowed. The fact that in the case of some of the resulting determinants the simple symmetric functions of the α's appear in the same element with those of the β's must not be considered an indication to the contrary of this. Indeed it is sufficient to point out that the form of every element in Garbieri's determinant is a bipartite function, and that an integral power of a binomial is a special case of such a function. For example, the bipartite

1	x	x^2	x^3	
a_1	a_2	a_3	a_4	1
b_1	b_2	b_3	b_4	y
c_1	c_2	c_3	c_4	y^2
d_1	d_2	d_3	d_4	y^3

degenerates into $(x+y)^3$ when $a_4, b_3, c_2, d_1 = 1,3,3,1$ and all the other a's, b's, c's, d's vanish.

12. Lastly, a momentary glance may be taken at Cauchy's double alternant, that is to say, the alternant which in our temporary notation is denoted by

$$D_{n;-1}.$$

This when the two sets of variables are identical is axisymmetric and admits of special treatment. Thus, using $D'_{3;-1}$ to stand for

$$\begin{vmatrix} \frac{1}{2a_1} & \frac{1}{a_1+a_2} & \frac{1}{a_1+a_3} \\ \frac{1}{a_2+a_1} & \frac{1}{2a_2} & \frac{1}{a_2+a_3} \\ \frac{1}{a_3+a_1} & \frac{1}{a_3+a_2} & \frac{1}{2a_3} \end{vmatrix}$$

and f_{rs} for $(a_r - a_s) \div (a_r + a_s)$ we have

$$2a_1 . 2a_2 . 2a_3 . D'_{3;-1} = \begin{vmatrix} 1+0 & 1+f_{12} & 1+f_{13} \\ 1-f_{12} & 1+0 & 1+f_{23} \\ 1-f_{13} & 1-f_{23} & 1+0 \end{vmatrix}.$$

But for this latter determinant may be substituted the four-line determinant

$$\begin{vmatrix} 1 & 1 & 1 & 1 \\ -1 & . & f_{12} & f_{13} \\ -1 & -f_{12} & . & f_{23} \\ -1 & -f_{13} & -f_{23} & . \end{vmatrix}$$

which on account of the cofactor of the (1,1)th element being equal to 0 may itself be replaced by

$$\begin{vmatrix} . & 1 & 1 & 1 \\ -1 & . & f_{12} & f_{13} \\ -1 & -f_{12} & . & f_{23} \\ -1 & -f_{13} & -f_{23} & . \end{vmatrix}.$$

We thus have finally

$$D'_{3;-1} = \begin{vmatrix} 1 & 1 & 1 \\ & f_{12} & f_{13} \\ & & f_{23} \end{vmatrix}^2 \div 2^3 a_1 a_2 a_3 \qquad \text{(VIII.1)}$$

$$= \left\{ \frac{a_2 - a_3}{a_2 + a_3} - \frac{a_1 - a_3}{a_1 + a_3} + \frac{a_1 - a_2}{a_1 + a_2} \right\}^2 \div 2^3 a_1 a_2 a_3.$$

There is a difference of form in the result when the given determinant is of even order. Thus, in the case of the fourth order, while we come as before to the equation

$$2^4 . a_1 a_2 a_3 a_4 . D'_{4;-1} = \begin{vmatrix} 1 & 1 & 1 & 1 & 1 \\ -1 & . & f_{12} & f_{13} & f_{14} \\ -1 & -f_{12} & . & f_{23} & f_{24} \\ -1 & -f_{13} & -f_{23} & . & f_{34} \\ -1 & -f_{14} & -f_{24} & f_{34} & . \end{vmatrix},$$

and partition the determinant on the right into the sum of a five-line and a four-line zero-axial determinant, it is not the latter but the former that vanishes, giving

$$D'_{4;-1} = \begin{vmatrix} f_{12} & f_{13} & f_{14} \\ & f_{23} & f_{24} \\ & & f_{34} \end{vmatrix}^2 \div 2^4 a_1 a_2 a_3 a_4. \qquad \text{(VIII.2)}$$

13. Underlying these results we have evidently the general theorem that *If all the elements of a zero-axial skew determinant be increased by* 1, *the resulting determinant is an exact square, whatever the order may be ;* the reason being that where the order is even the value of the determinant is unaltered by the change, and where the order is odd the new determinant is expressible as a zero-axial skew determinant of the next higher order. (IX.)

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VOLUME III.—PART 2.
1913.

CAPE TOWN:
PUBLISHED BY THE SOCIETY.

1913.

Issued June 12th, 1913.]

[Price 15s.

CONTENTS.

A NOTE CONCERNING THE PHYSICAL SIGNIFICANCE OF THE MEAN DIURNAL CURVE OF TEMPERATURE.

By J. R. Sutton, ScD., F.R.S.S.Af.

(Read July 17, 1912.)

The hourly average temperatures for the different months, or for the year, are sometimes subjected to elaborate processes of analysis for the purpose of eliciting, if possible, some relation bearing upon the enigma of the semi-diurnal oscillation of the barometer. But have these hourly averages any great scientific value? Is the mean diurnal curve of temperature, for example, that to which each daily curve tends to conform? Or, further, is the method of least squares applicable in the sense that the average value of all the observations is the most probable value? The original object of the present brief investigation was to test this point.

It is of course true that for any hour in any period, say a month, the sum of the squares of the deviations from the arithmetic mean temperature of that hour and month will be a minimum. For let T be the arithmetical mean temperature for any given hour of a month; t_1, t_2, t_3, . . . the individual temperatures for that hour for each day of the month; P the "most probable value" of the set of daily temperatures.
Then—

$$S = (P - t_1)^2 + (P - t_2)^2 + \ldots = \text{a minimum}.$$

$$\therefore \frac{dS}{dP} = 2nP - 2(t_1 + t_2 + t_3 + \ldots) = 0.$$

$$\therefore P = (t_1 + t_2 + t_3 + \ldots)/n = T.$$

This assumes, however, that each individual temperature is under some sort of compulsion to approximate to the mean value. There is no such compulsion, for the mean temperature curve of any assigned month in one year may be materially different from the mean temperature curve of that same month in any other year.

Any attempt to test the value of the arithmetic mean temperature in a practical way must necessarily involve great labour. The method adopted here, after various unsatisfactory trials, is the following :—

Let t be the temperature at any hour on any day at Kimberley. Then the temperature t' at the next hour will depend partly upon t and partly upon the meteorological elements of wind and moisture coexisting. That is to say, for given wind and moisture conditions, t'

July, 1911.

	XV.	XVI.	Diff.
	t.	t'.	$t - t'$.
	°	°	°
1	58·5	57·5	+1·0
2	61·0	60·2	+0·8
3	62·4	61·2	+1·2
4	66·5	65·3	+1·2
5	71·0	69·2	+1·8
6	74·4	73·5	+0·9
7	71·0	69·5	+1·5
8	65·7	64·8	+0·9
9	62·8	61·8	+1·0
10	55·3	57·0	−1·7
11	60·8	61·0	−0·2
12	62·0	63·6	−1·6
13	68·0	66·9	+1·1
14	54·0	53·0	+1·0
15	46·0	45·2	+0·8
16	58·0	58·0	0·0
17	59·2	59·0	+0·2
18	60·0	58·9	+1·1
19	63·3	62·9	+0·4
20	66·5	66·0	+0·5
21	54·4	55·0	−0·6
22	70·0	69·2	+0·8
23	73·0	71·0	+2·0
24	72·3	72·0	+0·3
25	73·7	71·0	+2·7
26	58·5	58·5	0·0
27	55·8	59·0	−3·2
28	54·0	53·0	+1·0
29	62·8	61·1	+1·7
30	64·0	65·2	−1·2
31	57·4	57·0	+0·4
	62·7	62·1	0·6

will be higher or lower according as t is higher or lower. We have then to find the most common value of $t - t'$ at any hour. For if the mean diurnal curve of temperature has a real physical significance the most common successive hourly values of $t - t'$ should give the same curve.

On account of the great labour of the inquiry it has only been possible to prosecute it for the months of January (as representing the summer) and July (as representing the winter). But for these two months it has been done for ten whole years of hourly temperature readings. As an illustrative example of the method the foregoing table will perhaps be sufficient.

Here the first column gives the dates; the second and third columns the Kimberley temperatures at 3 p.m. and 4 p.m.; the fourth column the differences, counted positive when t is the greater. When each July of the ten years 1902–11 has been treated in this way, particular values of $t - t'$ are counted and the total frequencies arranged in rows in the following way:—

July XV.–XVI.

$t - t'$.	No.	$t - t'$.	No.
Less than $0^{\circ}\cdot0$	24	$1^{\circ}\cdot3$	8
$0\cdot0^{\circ}$	14	1·4	5
0·1	10	1·5	14
0·2	6	1·6	5
0·3	15	1·7	7
0·4	18	1·8	10
0·5	11	1·9	6
0·6	17	2·0	5
0·7	14	2·1	4
0·8	19	2·2	6
0·9	16	2·3	4
1·0	20	2·4	4
1·1	14	Greater than $2\cdot4^{\circ}$	20
1·2	14		

That is to say, in the ten years 1902–11, between the hours 3 p.m. and 4 p.m., the temperature fell, for example, by $0^{\circ}\cdot3$, 15 times; by $0^{\circ}\cdot9$, 16 times; by $2^{\circ}\cdot0$, 5 times, and so on. In the Tables at the end will be found the total frequencies for each hour, arranged in sets of five consecutive differences.

A remarkable feature of the results given in these Tables is the fact that over a wide range of temperature differences there is no strong central value about which the frequencies cluster. It is, in fact, not possible to construct a satisfactory temperature curve based upon the most common differences of temperature between one hour and the next. There are some weak central values which, to some extent, disappear in the process of smoothing by Bloxam's method. If I am not mistaken these arise largely from a tendency to a concentration of the frequencies round differences of whole degrees. Every reader of a meteorological thermometer probably has more entries in his register in whole degrees than in any fraction thereof: *e.g.*, 50°·0 will occur more often than, say, 50°·2; and 48°·0 more often than, say, 47°·9. Consequently the difference 2°·0 will occur more often than, say, 1°·3. This is to be expected in a way, because the etched division indicating the degree, however fine it may be, has some breadth, and so takes up more of the scale than the imaginary divisions

July Temperature Variation.

Hour Ending	Normal Curve.	Component Curves.		
		A.	B.	C.
	$t-t'$.	$t-t'$.	$t-t'$.	$t-t'$.
	°	°	°	°
I.	+1·2	+0·1	+1·1	+2·0
II.	+1·0	+0·1	+1·1	+2·1
III.	+0·7	−0·1	+0·9	+1·9
IV.	+1·0	+0·2	+1·2	−1·9
V.	+0·7	0·0	+0·9	+1·9
VI.	+0·5	+0·1	+1·0	(+1·6)
VII.	+0·7	0·0	+0·9	+2·0
VIII.	−4·3	−3·0	−4·0	−5·0
IX.	−8·0	(−6·9)	−7·9	−8·9
X.	−5·5	−5·0	−6·1	−6·9
XI.	+4·2	−3·1	−4·0	−4·9
Noon	−3·0	−2·3	−3·1	−3·8
XIII.	−2·0	−1·3	−2·0	−2·7
XIV.	−1·2	0·0	−1·1	−1·8
XV.	−0·3	+0·3	−0·3	−0·9
XVI.	+1·0	(+1·6)	+0·9	0·0
XVII.	+5·3	+3·0	+5·0	+5·8
XVIII.	+6·1	+4·5	+5·9	+7·0
XIX.	+2·8	+1·9	+3·0	+3·5
XX.	+2·0	+1·0	+2·0	+2·9
XXI.	+1·7	0·0	+1·9	+2·9
XXII.	+1·4	+0·1	+1·1	+1·9
XXIII.	+1·2	+0·1	+0·9	+2·0
Midnight	+1·2	+0·1	+1·0	+1·9

JANUARY TEMPERATURE VARIATION.

Hour Ending	Normal Curve.	Component Curves.		
		A.	B.	C.
	$t-t'$.	$t-t'$.	$t-t'$.	$t-t'$.
	°	°	°	°
I.	+1·2	+0·1	+0·9	+1·9
II.	+1·1	+0·2	+1·2	+2·0
III.	+0·9	+0·4	+0·9	+1·8
IV.	+0·9	+0·2	+1·2	(+2·0)
V.	+0·8	+0·1	+0·9	+1·8
VI.	−0·8	−0·1	−1·0	−2·0
VII.	−5·0	−4·0	−5·0	−5·9
VIII.	−4·4	−3·1	−4·0	−5·4
IX.	−3·6	−3·0	−4·0	−4·9
X.	−3·0	?	−3·0	−4·1
XI.	−2·8	−2·1	−2·9	−3·4
Noon	−1·8	−1·2	−2·3	−2·9
XIII.	−1·1	−1·2	−1·8	−2·4
XIV.	−0·4	−1·1	−0·3	+0·3
XV.	+0·1	−0·9	0·0	+1·0
XVI.	+0·9	+0·1	+0·9	+1·9
XVII.	+1·5	+1·0	+1·8	?
XVIII.	+2·3	+1·1	+2·0	+2·9
XIX.	+4·0	+3·1	+4·0	+5·0
XX.	+3·1	+2·1	+2·9	+4·0
XXI.	+2·0	+1·0	+2·1	+3·0
XXII.	+1·5	+0·1	+0·9	+1·9
XXIII.	+1·4	0·0	+0·9	+2·0
Midnight	+1·3	0·0	+1·0	+1·9

that indicate the tenths, and hence readings to whole degrees should be the most frequent.* Apart from this, however, it is not unlikely that what is called the mean diurnal curve of temperature is, for Kimberley, made up of at least three superimposed component curves of the same period—curves proper perhaps to various outstanding types of weather. They are given below in smoothed values of $t-t'$, but rather in the way of inference from the results than of proof; and also, for comparison, the corresponding differences of the normal mean diurnal temperature curve. Of these three, marked A, B, and C respectively, the B curve resembles the normal curve; the A curve is probably proper to damp weather; while the C

* At any rate this is the most important reason.

curve may represent dry anti-cyclonic conditions. Whatever be the actual value of these three component curves, it seems clear that the normal mean diurnal temperature curve has no very important physical significance over and above what the B curve may have.

NOTE.—In the Tables of frequency-values of $t-t'$ at the end, there is a line marked "Less" at the top, and a line marked "Greater" at the bottom. The numbers in these lines are residuals, outside the range of the numbers in the body of the Tables. Thus, *e.g.*, between 2 p.m. and 3 p.m. in July there were—

34	times when	the temperature	rose	by	1°·1	to	1°·5	;
69	,,	,,	,,	,,	0·6	,,	1·0	;
76	,,	,,	,,	,,	0·1	,,	1·5	;
61	,,	,,	fell	,,	0·0	,,	0·4	;
25	,,	,,	,,	,,	0·5	,,	0·9.	

Besides this there were 45 residual frequencies, *i.e.*, 19 occasions when the rise was greater than 1°·5, and 26 occasions when the fall exceeded 0°·9.

JANUARY. FREQUENCY-VALUES OF $t - t'$.

	M.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	N.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	XXIII. M.
Less	18	22	34	26	27	20	40	48	17	30	23	26	29	17	38	26	40	21	62	34	51	16	23	11
−8°·0 to −7°·6							19																	
7·5 ,, 7·1							17																	
7·0 ,, 6·6							22																	
6·5 ,, 6·1							13																	
6·0 ,, 5·6							31	25																
5·5 ,, 5·1							18	29	12															
5·0 ,, 4·6							32	32	46															
4·5 ,, 4·1							13	42	35	31	22													
4·0 ,, 3·6							23	41	53	51	33													
3·5 ,, 3·1							13	23	38	53	52	18												
3·0 ,, 2·6							14	24	45	56	53	45	23	21										
2·5 ,, 2·1						13	5	15	18	32	47	70	45	31										
2·0 ,, 1·6						30			15		36	59	54	46	14									
1·5 ,, 1·1						44						36	49	41	35	14								
1·0 ,, 0·6						66						14	37	37	60	39								4
−0·5 ,, −0·1	17	12	21	20	23	43							18	37	37	35	18					10	13	18
0·0 ,, +0·4	37	44	42	66	54	41								20	36	46	38	11				45	40	40
+0·5 ,, 0·9	56	53	72	45	68	24								9	18	38	47	14			19	38	44	38
1·0 ,, 1·4	58	82	55	71	55										15	29	46	39		21	32	47	50	61
1·5 ,, 1·9	53	33	43	37	46											17	33	36		25	35	37	39	50
2·0 ,, 2·4	36	33	18	25	16											8	25	48		35	52	43	36	38
2·5 ,, 2·9																	17	34	18	32	43	24	15	10
3·0 ,, 3·4																		42	41	37	33			
3·5 ,, 3·9																		20	23	33				
4·0 ,, 4·4																		14	29	27				
4·5 ,, 4·9																			29	17				
+5·0 ,, +5·4																			33					
Greater	35	31	25	20	21	29	49	31	31	57	44	42	55	51	57	58	46	31	75	45	45	50	50	40

JULY. FREQUENCY-VALUES OF $t - t'$.

M.	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	N.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.	XXII.	XXIII.	M.
Less	25	27	42	32	34	47	21	11	52	30	16	26	15	21	19	24	24	17	17	29	22	28	29	19
−10°·5 to −10°·1									15															
10·0 ,, 9·6									29															
9·5 ,, 9·1									13															
9·0 ,, 8·6									31															
8·5 ,, 8·1									21															
8·0 ,, 7·6									39															
7·5 ,, 7·1								12	18	17														
7·0 ,, 6·6								13	17	27														
6·5 ,, 6·1								15	10	39	11													
6·0 ,, 5·6								24	18	44	23													
5·5 ,, 5·1								21	6	27	32													
5·0 ,, 4·6								40		32	50													
4·5 ,, 4·1								30		32	41	29												
4·0 ,, 3·6								40		14	40	59												
3·5 ,, 3·1								23		14	28	53	31											
3·0 ,, 2·6								23		9	26	47	55											
2·5 ,, 2·1								18		8	14	40	42	27										
2·0 ,, 1·6										5	11	23	62	58										
1·5 ,, 1·1												13	47	74	34									
1·0 ,, 0·6							16					11	29	62	69									
−0·5 ,, −0·1	19	16	28	18	32	21	26						16	33	76							(12)	10	9
0·0 ,, +0·4	32	43	45	53	46	70	59								61	63					28	26	38	44
+0·5 ,, 0·9	38	40	72	38	75	60	54								25	77				25	21	26	55	44
1·0 ,, 1·4	69	86	45	80	48	56	55									61			20	37	53	72	52	62
1·5 ,, 1·9	57	27	45	31	34	23	31									42			34	54	53	39	36	53
2·0 ,, 2·4	36	37	14	25	21	18	(30)									23			45	49	62	44	35	36
2·5 ,, 2·9																			44	49	27	24	26	20
3·0 ,, 3·4																	36	8	57	36	22	16	13	
3·5 ,, 3·9																	25	15	39	17				
4·0 ,, 4·4																	27	18	27					
4·5 ,, 4·9																	28	15	7					
5·0 ,, 5·4																	32	30						
5·5 ,, 5·9																	34	35						
6·0 ,, 6·4																	22	35						
6·5 ,, 6·9																	17	28						
+7·0 ,, +7·9																	31	75						
Greater	34	34	19	33	20	15	18	40	41	5	18	9	13	35	26	20	34	34	20	14	22	23	16	24

A NOTE ON THE EARTHQUAKES OF THE SOUTH AFRICAN TABLE-LAND.

By J. R. Sutton, Sc.D., F.R.S.S.Af.

(Read July 17, 1912.)

Occasional shocks of earthquake are felt on the South African Tableland. As a rule, although they extend over vast areas at a time, they are too slight to do much harm; but they may at times attain to some violence, and cause damage and loss of life. One, felt last February, was sufficiently severe to be recorded by seismographs in Europe. They seem to have some sort of relationship to barometric disturbances, and therefore in this respect are akin to the mud-rushes which were common in the Kimberley mines some years ago. Since the establishment of the observatory at Kenilworth there have been four earthquakes of sufficient intensity to be plainly felt. The following are the daily average values of the barometric pressure (from hourly readings) for a few days before and after these shocks :—

1. Earthquake at 10.13 p.m., July 31, 1903.

	Barometer.
July 28	26·332 inches.
29	·299
30	·278
31	·274
Aug. 1	·323
2	·300
3	·276

2. Earthquake at 10.35 p.m., Sept. 26, 1908.

	Barometer.
Sept. 21	26·278 inches.
22	·241
23	·212
24	·150
25	·164
26	·092
27	·003
28	·065
29	·104
30	·130

3. Earthquake at 8.10 p.m., Oct. 21, 1910.

	Barometer.
Oct. 18	26·134 inches.
19	·105
20	·074
21	·151
22	·046
23	25·991
24	26·014
25	·079
26	·133

Coincident with this earthquake there was also a small but rapid variation of atmospheric pressure not shown in the hourly numbers.

4. Earthquake (Two Shocks) at 3.5 p.m., and just before 4 p.m., Feb. 20, 1912.

	Barometer.
Feb. 16	26·083 inches.
17	·146
18	·136
19	·070
20	·022
21	·052
22	·052
23	·079
24	·128
25	·223
26	·280

Of course the diurnal oscillation of barometric pressure is superimposed on these daily averages, accentuating the disturbances very largely. For example, the hourly pressures on Feb. 20, 1912, were:—

		Barometer.
Feb. 20,	IX.	26·063 inches.
	X.	·061
	XI.	·053
	Noon	·041
	XIII.	·028
	XIV.	·004
	XV.	25·987
	XVI.	·967
	XVII.	·965
	XVIII.	·979
	XIX.	·997
	XX.	26·019
	XXI.	·028
	XXII.	·051
	XXIII.	·059

From which it appears that the two shocks of this day not only came when the barometer was at its lowest on the days' averages, but nearly at the time when it was lowest for the day itself.

It would be unsafe to argue from these few cases that an earthquake can only occur in South Africa when there is some amount of barometric disturbance. But it is not unlikely that when other conditions (say the flow of underground water carrying away lime in solution, and so making the support of the earth's crust at the spot unstable) are favourable to earth-movement, the passage of a barometric disturbance across the continent may decide the time when the movement shall take place. The idea that barometric disturbances have some influence over earth-movements is by no means a new one. The fact, *e.g.*, that the earthquakes of China are most frequent in summer, Mr. N. F. Drake explains as due to the rapid and strong variations of atmospheric pressure, assisted by the heavy rain-storms, which occur in summer. [See the *Bulletin* of the Seismological Society of America for March, 1912.]

A SHORT NOTE ON THE OCCURRENCE OF ASPERGILLOSIS IN THE OSTRICH IN SOUTH AFRICA.

By James Walker, M.R.C.V.S.

(Read October 16, 1912.)

(Plates IX., X.)

Introduction.

Numerous observations have shown that certain fungi belonging to the group Eumycetes are pathogenic for birds and may participate in an extensive internal process, as in the case of Pulmonary Mycosis (Pneumomycosis) or in a generalised infection in which the spores are probably carried by the blood stream, lodging in various parts of the body and producing serious lesions, and although in most cases no careful species examination was made, in all probability *Aspergillus fumigatus* was the species responsible.

The first recorded case of Pneumomycosis was observed in 1815 by Meyer in a jay. In 1841 Aspergillus infection was detected in the fowl; and later, cases were signalled in the pheasant, turkey, pigeon, duck, goose, swan, &c. This disease has also been recorded in the ostrich in America.

Existence in South Africa.

There is no doubt that Aspergillosis has existed in South Africa in the ostrich for some time, but, so far as the writer is aware, no cases have actually been recorded. In May, 1912, the writer observed the disease in an adult ostrich (No. 6); this bird was in experiment, and on post-mortem examination nodules were noted in the lungs and intestinal tract and a fungus growth was present in the hollow cavities of the bones of the sternum anteriorly. Since then cases have been noted in the Bedford, Albany, and Alexandria districts of the Cape Province, and there are reasons to suspect that it enjoys a wide range of distribution.

MORPHOLOGY.

A portion of the fungus growth noted in the bone cavities of ostrich No. 6 was collected at the time of post-mortem, and cultures were made from this for the purpose of studying its characters. These were found to correspond with those of *Aspergillus fumigatus*, and were as follows :—

A filamentous mycelium from which arises at right angles germinal hyphæ enlarged at their free end, and carrying individual basides on which are inserted chainettes of conidia dehiscent round in shape, size averaging 3 μ in diameter, greenish in colour.

Character of Culture.

On *bouillon lactose glycerine* flocons are visible in the medium at the 15th hour. The medium remains clear. The surface of the culture at first white becomes green-bluish and later green-blackish. On *potato, development* is likewise rapid, the growth becoming finally green-black.

Symptoms—Duration—and Course.

The disease runs an acute and sub-acute course. In the acute form as observed in young chicks (Transmission Experiments) the first indication that there is something amiss is a disinclination to feed, dullness, eyes kept partly closed, the affected chick stands or moves about slowly, the head is usually lowered and carried close to the body. The symptoms of Aspergillosis of the air-tracts consist primarily in acceleration of the respirations. The breathing gradually becomes more and more impeded and difficult and the beak is frequently kept partly open. On auscultation a rough breathing sound is heard chiefly during expiration.

In the sub-acute cases in adult birds a gradual loss of condition and emaciation is marked.

Duration.—In the acute form the disease runs its course in a few days. In the sub-acute form some weeks may elapse before death.

Transmission Experiments.

A number of transmission experiments were carried out, and the following is a summary of the results :—

I. *Aspergillus fumigatus* was transmitted by—

(*a*) The intravenous injection of a bouillon-lactose-glycerine-culture to the ostrich, pigeon, and fowl.

(*b*) The inhalation of portion of a culture (potato) to the ostrich and pigeon.

(*c*) The introduction of portion of a culture (potato) direct into the trachea of the ostrich.

(*d*) Ingestion of a bouillon-lactose-glycerine-culture to the ostrich and pigeon.

(*e*) Ingestion of a portion of intestines and contents of intestines, collected from a chick which died from ingestion of a culture, to the ostrich.

(*f*) Inoculation of the buccal mucous membrane, after scarification, with a culture to a chick aged a few days.

(*g*) Contact with a chick which had been dosed with Aspergillus culture.

In the following instances results were negative :—

(*a*) Two sheep and 2 cattle injected intravenously on the 25/7/12 remain apparently healthy to date, 10/9/12.

(*b*) One fowl put in inhalation experiment 26/7/12 likewise remains apparently healthy to date 10/9/12.

(*c*) Introduction of a portion of a culture (potato) into the trachea o two fowls has had no apparent ill-effects to date 10/9/12. Date of experiment 16/8/12 and 23/8/12 respectively.

(*d*) Three 9-months-old chicks inoculated buccal mucous membrane, after scarification, with a culture, show no ill-effects to date 10/9/12.

(*e*) The subcutaneous injection of an emulsion in bouillon of several nodules collected from the lungs of ostrich (No. 6) to the rabbit, guinea-pig, and ostrich.

(*f*) The subcutaneous injection of an emulsion in bouillon of portion of fungus growth collected from the hollow cavities of bones of the sternum of ostrich No. 6.

(*g*) The ingestion of portion of contents of small intestines of ostrich No. 6 in which were included nodules.

The negative results obtained from subcutaneous injection of nodules and ingestion of nodules indicate that infection takes place through the agency of spores only.

Summary of Cultural Experiments.

In several instances medium (potato) was inoculated for the purpose of ascertaining whether *Aspergillus fumigatus* could be recovered from affected organs. In the following the results were positive :—

(*a*) Inoculation of medium with nodules and scrapings of organs showing nodules, *e.g.*, lung, liver.

(*b*) Inoculation of medium with scrapings of lungs which on post-mortem showed pathological anatomical lesions of hyperæmia and œdema.

(*c*) Inoculation of medium with scrapings of liver which on post-mortem appeared normal (1 experiment).

In the following instances negative results were obtained:—

(*a*) Inoculation of medium with scrapings of lungs which on post-mortem showed hyperæmia and œdema (1 experiment).

(*b*) Inoculation of medium with scrapings of liver which on post-mortem presented no pathological appearances (1 experiment).

(*c*) Inoculation of medium with scrapings from kidneys of three ostriches which on post-mortem examination were found to be affected but in which the kidneys were apparently healthy.

PATHOLOGY.

Summary of Pathological Appearances and Seat of Lesions.

As the result of intra-venous injections of a culture, the most constant seat of lesions was found to be in the liver and lungs. In the former they appear in the form of isolated, disseminated, miliary opaque nodules averaging ·2 mm. in diameter in size. In the latter they also occur as isolated nodules from ·2 to ·5 mm. in diameter, white or yellowish in colour, firm in consistency.

Hyperæmia of the small and large intestines and vermiform appendices was observed in two cases. The kidneys presented no pathological changes.

Infection by inhalation produced a hyperæmic and œdematous condition of the lungs, with, in some cases, the appearance of nodules in the lung parenchyma, walls of the thoracic air-sacs and peritoneum.

The ingestion of cultures resulted in no marked pathological changes in the intestinal tract, but lung lesions were noted.

Inoculation of the buccal mucous membrane in young chicks resulted in one instance in lung and intestinal lesions with an exudate into the peritoneal cavities, and in another nodules were detected in the lungs.

Introduction of spores direct into the trachea caused hyperæmia and œdema of the lungs and disseminated nodules, and nodules in the walls of the thoracic air-sacs and on the peritoneum, distension of the intestines with gas and an emphysematous condition of the subcutaneous tissue of the body.

The most constant seat of lesions in experimentally produced cases was found to be in the lungs (Pneumomycosis).

Microscopical Appearances.

Portions of the liver and lungs collected from a 9-months-old chick which had died from intravenous inoculation of a culture were fixed in 10 per cent. formalin and embedded in paraffin. Sections were stained by various methods, *e.g.*, giemsa, hæmotoxylin and eosin, weigert, and by Mallory's method.

The former was found to give the best results. Liver sections : With the 8-mm. objective and 4 ocular, a number of mycelial filaments varying in length, and numerous disseminated nodules are visible, the latter can be detected with the naked eye.

With the 1/12th oil immersion and 4 ocular, the filaments (which are found to be, in some instances, branched) show clear round spaces which give them a beaded appearance. The reaction on the part of the tissues manifests itself in small groups of epitheloid cells and in the formation of nodules. The latter are usually well defined from the surrounding tissue, they are made up of a collection of epitheloid cells amongst which eosinophile cells are sometimes seen. In some of the nodules short filaments are visible, others appear to be completely free of them. In sections of lungs the nodules have the same appearances.

In sections made from the lung of an adult ostrich (subacute case) the cells composing the nodules were found on microscopical examination to have undergone degeneration and to have lost their staining affinity. The nodules were frequently found to have at their outer margin a zone of connective tissue corpuscles, and fibres.

CONCLUSIONS.

Aspergillosis occurs in the ostrich in South Africa.

In cases of natural infection in adult birds the disease may run a subacute course with symptoms of emaciation.

Infection is transmissible to young chicks by intravenous inoculation, ingestion, and inhalation of spores, by introduction of spores direct into the trachea, by inoculation of the buccal mucous membrane; and in one experiment a perfectly healthy chick which was kept for three or four days in contact with a chick which had been the subject of an ingestion experiment, died and on post-mortem was found to be affected. The disease runs an acute course and is fatal.

Inoculation of medium (potato) with portions of affected organs, and with portion of contents of vermiform appendices and large intestines collected from chicks in ingestion experiments resulted in recovery of the fungus.

The inoculation of potato medium with portions of affected organs serves as a simple method of diagnosis.

The most constant seat of lesions in experimentally produced cases was found to be in the lungs.

The lesions consist of tubercle-like formations in the affected organ.

In acute cases these are sometimes absent.

From the fact that the fungus has been recovered from the contents of the vermiform appendices and large intestines of artificially infected birds we may presume that the disease may be disseminated by the fæces.

EXPLANATION OF PLATES IX., X.

Fig.

1. Lung of pigeon (inhalation experiment) showing filaments of *Aspergillus fumigatus.*
2. Lung of ostrich showing Aspergillus nodule (experiment case).
3. Liver of ostrich showing Aspergillus nodule (experiment case).
4. Liver of ostrich showing Aspergillus filaments (experiment case).

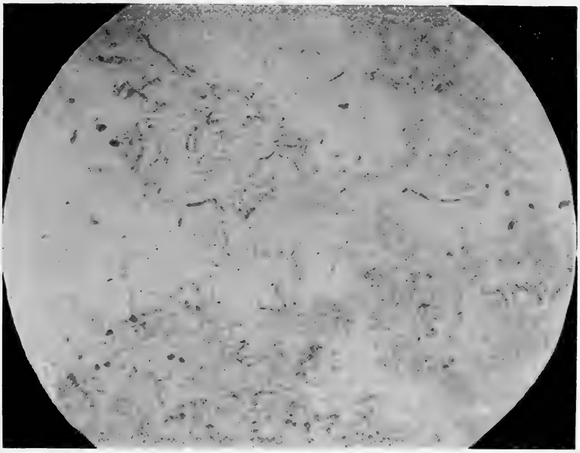

Fig. 1.

Section of lung of pigeon showing mycelium of *Aspergillus fumigatus* resulting from introduction of spores into trachea. (Giemsa stain.)

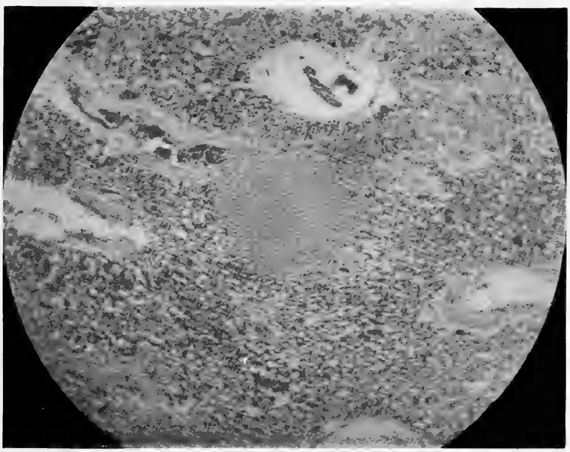

Fig. 2.

Section of lung of ostrich showing *Aspergillus* nodule resulting from intravenous injection of spores of *Aspergillus fumigatus.* (Giemsa stain.)

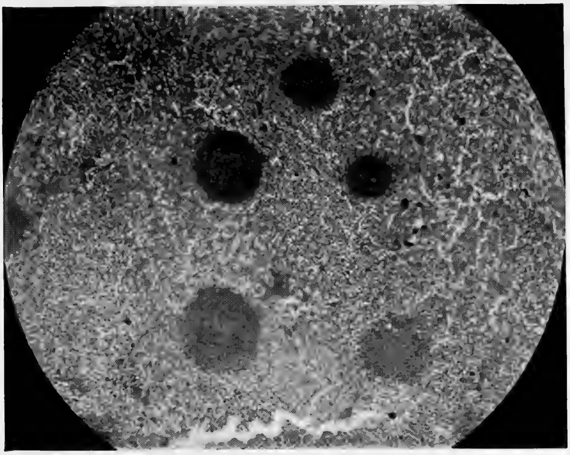

Fig. 3.

Section of liver of ostrich showing *Aspergillus* nodules, resulting from intravenous injection of spores of *Aspergillus fumigatus*. (Stained by Weigert's method.)

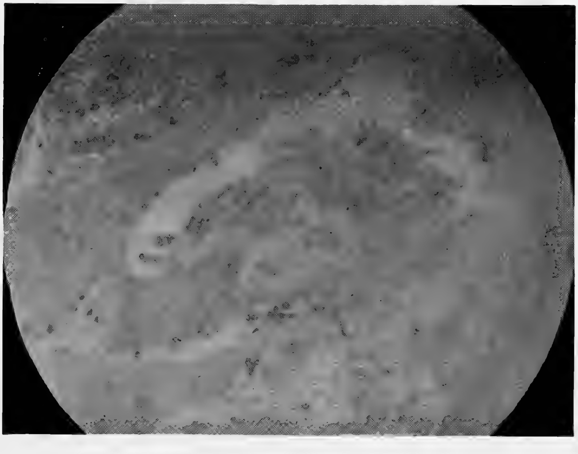

Fig. 4.

Section of liver showing mycelium of *Aspergillus fumigatus* resulting from intravenous injection of *Aspergillus fumigatus*. (Giemsa stain.)

A PRELIMINARY SURVEY OF THE METEOROLOGY OF KIMBERLEY.

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(Received October 9, 1912.)

(Read October 16, 1912.)

The present paper is intended as a further contribution to the meteorology of the Table-land of South Africa, arranged in a form suitable to the requirements of the physicist. Earlier instalments of the same series appeared from time to time in the *Transactions* of the South African Philosophical Society. The results given are deduced from observations made at Kenilworth (Kimberley) during the fifteen years 1897–1911. They show, in addition to yearly means and totals, deviations from the monthly mean values of all the more important recognised meteorological elements referred to the deviations from the monthly mean wind-direction resultant as argument. They are almost entirely statistical and tabular, and require very little in the way of explanatory setting at this time. Such results as these made at various places throughout the world have a certain amount of importance in view of the researches of Hildebrandsson and others on the centres of action of the atmosphere, and for other reasons.

Table 1 gives the mean monthly direction of the wind deduced from the continuous records of an Osler anemometer. The Table shows the north and east components in hours; the azimuth measured from the east point round by north; and the magnitude of the resultant. The north component is at its maximum in February and July, and at its minimum in May and October; while the east component has one maximum in June and one minimum in December. Thus there is a double oscillation in the year, the resultant direction starting from about north in January, tending gradually to about east in May, turning slightly towards the north in June and July, after which it travels forward from east round by south and west for the rest of the year. The mean direction is about east by north and the magnitude of the resultant 1,083 hours. Table 2 shows that the resultant in any one year will probably not differ greatly from this mean value either in direction or magnitude—1897 and 1911 being exceptional years.

Table 3 gives the monthly deviations from the monthly means of

Table 1. The azimuths are counted *plus* when the deviation is counter-clockwise up to 180°, and minus when it is clockwise up to the same angular distance. Thus the mean azimuth in January, 1897, was 122°, and because the normal mean azimuth for January is 85° the deviation appears as +37°. The individual monthly azimuths vary much more widely from the normal means than the annual ones do, the range of deviation being the best part of two right angles on one side or the other of the normal. So also the monthly deviations of the magnitude of the resultants given in Table 4 are considerable.

	Kenilworth.	Kimberley.	Difference.
	Inches.	Inches.	Inch.
Jan.	26·047	25·970	·077
Feb.	·080	26·013	·067
Mar.	·063	25·993	·070
April	·202	26·131	·071
May	·190	·117	·073
Jun.	·319	·242	·077
July	·214	·140	·074
Aug.	·234	·161	·073
Sept.	·165	·096	·069
Oct.	·070	·000	·070
Nov.	·041	25·967	·074
Dec.	·023	·951	·072
Year	26·137	26·065	·072

Table 5 gives the deviations of each month's mean wind velocity from the normal means. The normal means are shown at the foot of the Table. If this Table could be entirely trusted, the last column (showing the annual deviations) would indicate a more or less gradual falling off in the velocity of the wind year by year. It is probable, however, that this result is partly real and partly due—

(1) To some wearing of the bearings of the Robinson anemometer, and (2) to some gradually increasing obstruction to the exposure of the instrument by growing trees. From a meteorological point of view these trees are a great nuisance. They seriously handicap not a few of the observations made at Kenilworth, and cannot, besides, by any stretch of the imagination, be called beautiful. As to the wearing of the bearings, this, such as it is, is caused by the grit which is blown about in every dust-storm, and which penetrates everywhere.

Table 6 gives the *plus* and *minus* values of barometric pressure for

Kenilworth derived from readings of a large observatory standard barometer—the readings being made three times a day, at VIII., XIV., and XX., civil time. The mean of the pressures at these hours is practically the same as the mean of the hourly readings.

The late Mr. G. J. Lee took a series of meteorological observations from 1890–7 at his own second-order station in Jones Street, Kimberley. His observations of pressure were made at VIII. and XX. with a small Fortin barometer, and considering the difference of altitude between Kimberley and Kenilworth, they compare very well with those of Kenilworth. The Jones Street results have been computed and shown in Table 7. The table on the opposite page gives the respective monthly means for 1897.

After reducing the Kimberley annual means to the Kenilworth level, and smoothing the values in threes by Bloxam's method, we have the following series, some corresponding values for Durban and Mauritius being added for purposes of comparison :—

	Kenilworth.	Durban.	Mauritius.
	Inch.	Inch.	Inch.
1890	(−·007)	+·011	+·014
1	−·010	−·009	+·002
2	−·012	−·011	+·005
3	−·012	−·013	−·009
4	−·005	−·002	−·004
5	+·003	+·004	−·006
6	+·004	·000	·000
7	+·009	+·001	−·003
8	+·010	+·006	−·003
9	+·008	+·006	+·006
1900	+·007	+·011	+·017
1	·000	−·003	
2	−·004	−·005	
3	−·005	−·011	
4	−·003	−·007	−·004
5	+·003	−·003	+·001
6	+·001	+·003	−·007
7	−·001	+·005	−·010
8	−·002	(·000)	−·013
9	−·006		−·016
1910	+·001		
11	(+·013)		

Thus the irregular oscillations of pressure of long period, in the southern anticyclone belt, affect Kimberley and Durban similarly, but not Mauritius.

Table 8 gives the monthly deviation of the duration of sunshine from the normal means—shown as in the other Tables at the foot; and Table 9 the cloudiness of the sky. The numbers in these two Tables are, as a rule, the inverse of each other, the cloudiness tending to a maximum when the sunshine is a minimum.

Table 10 gives the monthly durations of rainfall in hours. The yearly deviations are shown in the last column.

Tables 11 and 12 give the approximate duration of electrical phenomena from eye and ear observations. The numbers in these two Tables, especially the latter, must be regarded as lower limits, for some thunder must escape hearing, and some lightning must escape attention on account of the obstruction to the horizon by trees.

The five Tables 8–12 are in fair agreement with each other; but neither exhibits such concordance with Table 6 as might have been expected.

Table 13 gives the deviation values for what is called the "temperature in the sun" as registered by a maximum black bulb *in vacuo*. In this Table the year 1909 is remarkable, every month save February showing a temperature higher than the normal mean of the month. Of the year 1897 the same may be said, though to a less degree. The year 1909 was the most clouded year of the period, while, curiously enough, 1897 had the least cloud. The monthly maximum temperatures in the shade show no such agreement (Table 14).

Tables 15 and 16 give minimum temperature deviations, in the shade and over a grass lawn respectively.

Tables 17, 18, 19 give respectively the temperatures of the dry bulb, the temperatures of the dew-point, and the relative humidities deduced from hourly readings of the dry and wet bulb thermometers.

Table 20 is supplementary to the general purpose of this paper. It gives the rainfall of Kimberley from 1877 to 1896, as observed by the late Mr. F. W. Matthews, and the rainfall of Kenilworth from 1894 to 1911.

Comparing now the monthly *plus* and *minus* values of the deviation from the normal wind direction with the *plus* and *minus* values of the other elements (leaving out zero deviations), we have the following results:—

	Like Sign.	Unlike Sign.
Magnitude of resultant	93 times	82 times
Barometric pressure	104	68
Sunshine	82	83
Cloud	88	74
Thunderstorms	82	81

	Like Sign.	Unlike Sign.
Lightning	82	82
Max. temperature in sun	84	87
,, ,, ,, shade ...	93	78
Min. ,, ,, ,, ...	96	75
Min. over grass.....................	93	78
Dry bulb	102	69
Dew-point	95	76
Relative humidity	86	88

The meaning of this summary will be understood from a single example: In 172 months the barometric-pressure deviation and the wind-resultant deviation were both positive or both negative (*i.e.*, they had the same sign) 104 times; while in the remaining 68 times the deviations of the two were in opposite directions (*i.e.*, they had unlike signs).

But on the whole it may be said that the above summary shows no very strong dependence of the greater number of the elements upon the deviation of the wind-direction resultant from its normal mean direction. If, however, the comparison be made month by month, a much better case is made out. For example, if the sunshine deviations be taken in periods of three months each, we get the following numbers:—

	Like Sign.	Unlike Sign.
Dec., Jan., Feb.	27 times	14 times
Mar., April, May	20	23
June, July, Aug.......................	24	18
Sept., Oct., Nov......................	11	28

That is, in December–February and in June–August the sunshine deviations and the azimuth deviations agree in the majority of cases. Now in the period December–February the mean resultant direction of the wind is nearly north, and in the period June–August nearly east. Hence in the first period an excess of sunshine will accompany a deviation to the west in the direction of the wind; and in the second period there will be an excess of sunshine when the vane tends more to the north. Again, in the period September–November the mean resultant is southerly; and in this period we get less sunshine when the deviation is towards the east, and more sunshine when the deviation is towards the west. Of the cloudiness of the sky practically the opposite may be said. Thus on the whole a westerly tendency in the wind indicates clearer skies, and an easterly tendency more cloud, and also more thunderstorms and more sheet-lightning. The following are the numbers for these three elements:—

1. Cloud.	Like Sign.	Unlike Sign.
Dec., Jan., Feb.	12 times	28 times
Mar., April, May	27	14
June, July, Aug.	21	20
Sept., Oct., Nov.	28	12

2. Thunderstorms.		
Dec., Jan., Feb.	15 times	26 times
Mar., April, May	19	24
June, July, Aug.	22	18
Sept., Oct., Nov.	26	13

3. Lightning.		
Dec., Jan., Feb.	14 times	29 times
Mar., April, May	25	18
June, July, Aug.	22	17
Sept., Oct., Nov.	21	18

In summer the maximum temperature in the shade rises or falls according as the deviation of the resultant wind direction is positive or negative, whereas in the spring the case is the other way about. Thus in both seasons a deviation to the west in the vane means an increase of temperature. The minimum temperatures, both in the shade and over the grass, on the other hand, are higher when the vane tends easterly.

Lastly, in the summer the temperature of the dew-point rises as the vane tends easterly; whereas for the rest of the year the rise corresponds with a positive deviation in the resultant direction of the wind.

TABLE 1.

MEAN RESULTANT DIRECTION OF THE WIND, 1897–1911.

	North.	East.	Azimuth.	Magnitude.
	Hours.	Hours.	°	Hours.
Jan.	+104	+ 9	85	104
Feb.	+114	+ 77	56	137
Mar.	+ 65	+128	27	143
April	+ 46	+131	19	139
May	+ 5	+149	2	150
June	+ 25	+183	8	184
July	+ 73	+206	19	219
Aug.	+ 3	+107	2	107
Sept.	− 6	+ 85	356	85
Oct.	−100	+ 19	280	102
Nov.	− 72	− 15	258	74
Dec.	− 11	− 23	205	26
Year	+245	+1055	13	1083

TABLE 2.

ANNUAL RESULTANT DIRECTION OF THE WIND.

	North.	East.	Azimuth.	Magnitude.
	Hours.	Hours.	°	Hours.
1897	− 500	− 245	244	557
1898	+ 296	+1420	12	1451
1899	+ 128	+1542	5	1547
1900	+ 167	+ 887	11	903
1901	+ 468	+ 878	28	995
1902	+ 396	+1168	19	1233
1903	+ 199	+ 568	19	602
1904	+ 277	+1205	13	1236
1905	+ 844	+ 931	42	1257
1906	+ 592	+ 817	36	1009
1907	+ 453	+1420	18	471
1908	+ 135	+ 599	13	614
1909	+1114	+1442	38	1822
1910	+ 459	+1431	18	1503
1911	− 18	+1701	359	1701

TABLE 3.

Monthly Resultant Directions of the Wind in Deviations from the Monthly Means.

(1) Azimuth.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	°	°	°	°	°	°	°	°	°	°	°	°
1897	+ 37	+148	− 29	+100	+111	− 61	− 52	+ 3	− 78	− 25	− 23	+ 23
1898	− 44	− 33	+ 16	− 7	+ 7	+ 1	+ 3	+ 21	− 61	− 34	−157	− 57
1899	− 8	− 29	− 19	+ 3	+ 2	0	− 8	− 8	+ 13	− 45	+ 60	+ 70
1900	+ 40	− 15	+ 35	− 11	− 14	− 11	+ 2	− 34	− 56	− 38	− 53	− 62
1901	+ 88	− 31	− 5	+ 10	− 29	+ 20	− 19	+ 35	+ 27	+ 66	− 47	− 62
1902	+ 46	+ 1	− 20	− 37	+ 19	− 34	+ 5	− 91	− 16	+ 23	+ 10	+ 88
1903	+162	+ 10	−102	− 58	− 21	− 15	− 3	+ 34	+ 13	− 42	+ 6	− 61
1904	− 31	− 18	+ 9	+ 4	− 20	+ 40	− 14	− 29	+ 39	+ 3	− 21	+ 56
1905	+ 1	+ 32	− 1	+ 27	+ 34	− 72	+ 17	− 62	+ 23	?	+112	−153
1906	+ 23	+ 44	− 9	− 39	0	+ 58	0	+ 34	− 11	+ 42	+162	+165
1907	− 4	+ 2	+ 13	− 9	− 8	+ 2	− 14	− 19	+ 39	+ 55	0	−116
1908	+ 31	+ 42	− 74	− 67	+ 17	− 23	+ 18	+ 41	− 20	− 37	− 49	−140
1909	− 44	− 5	+ 11	+ 28	− 1	+ 32	− 2	+ 59	+ 13	− 34	− 3	− 31
1910	− 10	− 7	− 15	+ 26	+ 1	+ 6	+ 9	− 55	0	+ 90	+ 48	+104
1911	−128	+ 1	+ 2	− 16	− 2	− 6	− 1	− 35	− 4	+ 40	+113	+ 24

TABLE 4.

Monthly Resultant Directions of the Wind in Deviations from the Monthly Means.

(2) Magnitude in Hours.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1897	+ 10	− 84	− 10	+ 53	−113	+ 63	−181	+ 92	− 28	+132	+272	− 2
1898	− 4	+ 58	+ 49	+ 41	+ 45	+ 70	+ 32	+193	+ 75	+162	− 18	+ 31
1899	− 35	− 31	+ 8	+126	+124	+ 31	+ 73	+ 32	− 57	− 55	+ 84	+ 36
1900	+ 57	− 30	+ 22	+ 42	+ 43	+117	+ 30	− 13	+ 10	+ 1	+ 52	+ 3
1901	+ 93	+ 4	+ 63	− 9	− 72	+122	− 86	+117	+ 34	+ 8	+ 88	+ 86
1902	− 29	+ 22	+ 62	+ 24	+ 64	− 19	+ 36	− 38	− 11	+ 50	+202	+ 81
1903	− 62	− 87	− 70	− 7	− 35	− 54	− 62	− 21	+ 53	+ 72	+ 12	+ 41
1904	+ 83	+ 55	+158	− 98	+ 67	− 61	+ 9	+ 1	+ 40	− 50	+ 5	+ 118
1905	+110	+ 39	+ 50	+ 64	−100	−113	+ 80	− 52	− 22	?	+ 72	+ 71
1906	+ 89	− 24	− 32	− 40	− 23	− 13	− 27	− 55	− 14	+ 28	+ 70	+ 52
1907	+ 72	+ 51	− 17	+ 94	− 34	+ 36	+ 53	− 9	+118	+ 50	+ 86	+ 17
1908	− 61	+ 67	−108	− 51	+ 60	− 16	+ 72	− 45	+ 10	+114	+ 2	− 14
1909	+306	+198	+ 28	+ 73	+ 42	+162	+ 3	+ 78	+ 16	− 45	+ 42	+ 137
1910	+ 56	+ 14	+116	+ 72	−119	+ 60	− 8	+ 62	+ 55	+ 49	− 34	− 3
1911	− 27	+ 45	+132	+101	+155	+ 37	+ 40	+ 90	− 8	+ 49	− 9	+ 173

TABLE 5.

MONTHLY VELOCITIES OF THE WIND. DEVIATIONS FROM THE NORMAL MONTHLY MEANS, IN MILES AN HOUR.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1897	+0·9	+1·4	+1·5	+1·8	+1·8	+1·5	+1·6	+1·8	+1·1	+1·3	+1·7	+2·0	+1·5
1898	+1·4	+1·1	+0·4	+1·4	+2·9	+0·7	+2·1	−0·1	+0·5	+1·7	+0·6	+1·3	+1·1
1899	+1·2	+1·5	+0·7	+1·0	+1·1	+0·4	+1·5	+1·4	−0·7	+0·2	−1·0	−0·7	+0·6
1900	−0·4	+0·6	+0·3	−0·6	−1·0	+0·8	+0·7	+0·2	−0·2	+0·6	+0·7	+0·3	+0·1
1901	+1·4	+1·0	+0·3	−0·2	+0·7	+0·7	−0·2	−0·3	+0·5	+0·1	+0·9	+0·5	+0·4
1902	+0·6	+0·1	−0·3	−0·3	−0·1	−0·1	+0·3	+1·0	+1·6	+0·7	+0·6	−0·1	+0·3
1903	+1·0	+0·4	+1·0	+0·5	+0·3	+0·7	+0·1	−0·4	−0·4	+0·3	−0·3	−0·6	+0·2
1904	−1·4	−0·9	−1·1	−1·1	−1·2	−0·6	−0·9	−1·6	−0·3	−0·5	−0·3	+0·4	−0·8
1905	0·0	−0·3	−0·1	−1·1	−0·6	−0·4	−1·2	−0·6	−0·5	−1·4	−1·2	−0·9	−0·7
1906	−1·6	−1·4	+0·5	−0·4	−0·7	+0·1	−0·3	0·0	+0·1	−0·2	+0·1	+0·8	−0·3
1907	−0·4	−0·6	−0·4	+0·6	0·0	−0·5	−0·6	−1·2	−1·0	0·0	−0·2	−0·3	−0·4
1908	+0·2	−0·2	+0·8	+0·3	−1·3	−0·8	−0·9	−0·1	−0·6	−1·5	+0·6	−1·0	−0·4
1909	−1·4	−1·3	−1·4	−1·2	−0·9	−1·1	−0·8	−0·2	−0·9	−0·2	−0·2	−0·7	−0·9
1910	−0·1	−1·0	−1·4	−0·6	−0·5	−0·5	−0·6	−0·3	+0·2	−1·4	−1·1	−0·9	−0·7
1911	−1·0	+0·3	−0·3	+0·1	−0·6	−1·4	−0·2	+0·3	−0·2	−0·2	−0·6	+0·6	−0·3
Mean......................	6·0	5·5	4·8	4·2	4·2	4·1	4·1	5·1	6·0	6·4	6·6	6·3	5·3

TABLE 6.

MONTHLY BAROMETRIC PRESSURES. DEVIATIONS FOR THE NORMAL MONTHLY MEANS, IN INCHES.

(KENILWORTH.)

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1897 ..	+·026	+·022	–·022	+·049	–·014	+·049	–·054	+·022	+·002	–·018	–·005	·000	+·004
1898...	–·012	+·051	–·010	+·018	–·012	+·028	–·002	+·104	+·012	–·011	–·031	–·005	+·011
1899...	–·005	–·035	+·014	+·032	+·070	+·041	–·011	–·030	+·012	–·019	+·034	+·005	+·009
1900...	–·010	+·025	+·016	+·032	+·011	+·002	–·062	–·032	+·003	–·016	–·019	+·019	–·003
1901...	–·024	–·001	·000	+·014	+·013	+·047	–·001	+·031	+·011	+·046	–·013	–·011	+·008
1902...	–·014	+·027	–·012	–·058	+·015	–·055	–·030	–·052	–·029	–·066	+·002	+·024	–·010
1903...	–·005	+·029	–·030	–·081	–·048	–·014	–·033	–·002	+·053	–·020	–·035	–·014	–·017
1904...	+·009	–·039	+·003	–·013	+·014	–·003	+·001	+·011	+·039	–·024	+·023	+·040	+·005
1905...	+·004	–·001	+·035	+·031	–·040	–·120	+·059	–·016	–·047	+·012	+·033	–·005	–·004
1906...	+·024	+·018	+·021	+·007	–·001	–·029	+·021	+·009	–·037	–·002	+·009	–·012	+·002
1907...	+·012	–·032	+·010	–·043	–·058	+·006	+·063	+·055	+·006	+·016	–·039	+·014	·000
1908...	+·028	–·028	–·034	–·046	+·072	–·033	+·037	–·023	–·028	– 053	–·014	+·004	–·010
1909...	–·015	–·011	+·004	+·006	–·020	+·041	+·017	–·037	–·001	–·007	+·017	–·021	–·003
1910...	+·017	–·024	–·032	+·017	–·010	–·028	–·038	–·034	–·014	+·008	+·035	–·010	–·010
1911...	–·034	–·001	+·031	+·031	+·002	+·066	+·039	–·004	+·017	+·021	–·010	–·038	+·011
Mean	26·021	26·058	26·085	26·153	26·204	26·270	26·268	26·212	26·163	26·088	26·046	26·023	26·133

TABLE 7.

Monthly Barometric Pressures. Deviations from the Normal Monthly Means, in Inches.

(Kimberley.)

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1890 ...	−·035	−·050	+·018	−·022	+·009	+·027	−·047	−·030	+·044	+·029	+·013	+·002	−·003
1891 ...	+·009	−·017	+·013	+·015	−·037	−·074	+·074	+·042	+·008	+·024	+·036	−·009	+·007
1892 ...	−·022	−·022	−·035	−·021	−·025	−·012	+·029	−·048	−·041	−·008	−·043	−·021	−·021
1893 ...	−·035	−·012	+·043	−·016	+·017	−·019	+·018	+·002	−·071	−·021	−·012	−·021	−·010
1894 ...	+·028	+·047	−·015	+·031	·000	−·019	+·004	+·003	+·003	−·029	+·002	+·020	+·007
1895 ...	+·006	−·015	+·005	−·006	+·017	+·037	−·059	−·006	+·028	+·004	+·012	−·009	+·001
1896 ...	+·021	+·030	+·006	−·040	+·018	−·005	+·019	+·002	+·010	+·023	+·010	+·043	+·012
1897 ...	+·029	+·040	−·034	+·046	−·006	+·067	−·039	+·038	+·020	−·023	−·018	−·005	+·010
Mean...	25·941	25·973	26·027	26·085	26·123	26·175	26·179	26·123	26·076	26·023	25·985	25·956	26·055

TABLE 8.

Duration of Sunshine. Deviations from the Normal Monthly Means, in Percentages of the Optimum.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1897	−5	+7	−6	+2	+3	+6	+7	−1	+9	+4	+2	−8	+1
1898	−16	−14	+3	0	−7	+4	+8	+1	+5	+7	0	+1	−1
1899	0	+3	−4	−12	−2	+1	−10	−5	−3	−3	−1	0	−3
1900	−2	+8	−3	−5	+3	−1	−5	−4	+7	0	+2	−6	−1
1901	+8	0	−2	+2	+12	−3	+5	−1	−4	−7	+4	+4	+1
1902	+6	+4	+3	+1	+9	−2	+3	−1	−2	+7	+13	+5	+4
1903	+9	−3	+9	+6	+1	+3	−1	+3	+7	+7	+4	+2	+4
1904	−10	−1	−4	+7	+7	−3	−2	+5	−5	−2	−1	+4	−1
1905	+2	−5	+5	+4	−2	−2	+7	−1	−7	−1	−4	−5	−2
1906	+1	+11	+4	+12	−1	+5	+6	+10	+4	+1	−9	+3	+3
1907	−2	0	−8	−10	−7	0	+1	+6	−3	−1	+6	−3	−2
1908	+10	+2	+5	+5	+7	+2	−3	−2	−8	0	+1	+3	+1
1909	−6	−10	+1	−1	−7	+3	−2	−6	+1	+2	−3	−5	−3
1910	+3	−2	−1	+2	−3	−5	−7	−3	+4	−6	−3	−2	−2
1911	+2	+5	−8	−9	−12	−3	−4	−4	+2	−3	−7	+5	−3
Mean	73 %	72 %	75 %	79 %	80 %	84 %	84 %	85 %	79 %	78 %	79 %	77 %	79 %

TABLE 9.

Cloudiness of the Sky. Deviations from the Normal Monthly Means in Percentages of the Sky.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1897	− 1	−15	0	− 1	− 3	− 8	− 9	− 1	−17	− 9	−11	− 3	−7
1898	+17	+ 7	− 6	− 2	+ 4	−10	−12	0	−12	−10	− 4	− 1	−3
1899	+ 3	− 6	+ 3	+15	+ 2	− 2	+14	+ 8	+ 2	+ 4	− 1	+ 2	+3
1900	− 4	−11	+ 1	+ 9	− 6	+ 4	+ 6	+ 4	− 6	+ 3	− 6	+ 4	−1
1901	−12	+ 5	0	0	−18	+ 6	− 9	− 5	+ 7	+14	− 2	− 4	−2
1902	−11	− 2	− 6	− 6	−10	− 3	− 1	− 1	+ 5	−10	−17	0	−6
1903	− 7	+ 7	−10	− 4	− 1	− 3	+ 2	− 4	− 8	−12	− 9	0	−5
1904	+10	0	+ 7	− 8	− 9	+ 3	− 4	− 6	+ 7	+ 3	+ 3	−11	−1
1905	− 2	+ 2	− 2	+ 3	+10	+ 9	− 7	+ 7	+12	0	+ 8	+ 3	+3
1906	+ 3	+12	− 4	−13	0	− 2	− 2	−12	0	+ 1	+22	− 6	−2
1907	+ 8	+ 2	+10	+ 7	+ 9	+10	− 3	−11	+ 2	+ 7	− 9	+ 6	+3
1908	−16	− 6	−12	−17	− 9	− 3	+ 3	+ 3	+16	0	− 5	0	−4
1909	+17	+16	+ 9	+ 7	+16	0	− 4	+ 9	− 3	− 2	+ 3	+ 8	+6
1910	− 2	+ 8	+ 5	+ 2	0	+ 3	+11	+ 8	− 1	+ 8	+ 9	0	+4
1911	− 4	− 2	+11	+13	+17	+ 2	+ 8	+ 4	− 1	+ 5	+16	− 5	+5
Mean	42%	44%	38%	30%	26%	19%	18%	17%	29%	34%	33%	37%	31%

TABLE 10.

MONTHLY DURATION OF RAINFALL, IN HOURS.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.	Year.
1897	44	19	40	14	11	...	...	8	...	11	...	23	170	−154
1898	116	54	36	22	42	...	4	3	6	13	27	22	345	+ 21
1899	51	34	46	74	24	9	42	10	10	48	42	35	425	+101
1900	42	28	80	72	10	20	35	6	...	27	27	72	419	+ 95
1901	20	46	87	35	2	5	2	8	25	39	11	41	321	− 3
1902	48	56	34	36	7	26	8	5	54	20	13	25	332	+ 8
1903	23	60	18	41	24	7	7	...	3	28	20	35	266	− 58
1904	66	57	41	12	16	25	...	4	2	36	23	33	315	− 9
1905	37	59	52	26	31	4	...	4	22	10	37	49	331	+ 7
1906	55	36	56	9	18	8	2	...	3	21	58	37	303	− 21
1907	63	58	74	95	59	11	2	...	20	30	18	48	478	+154
1908	23	30	40	18	6	6	38	16	23	10	16	34	260	− 64
1909	38	81	38	39	49	...	...	2	6	18	13	42	326	+ 2
1910	33	29	47	4	3	18	12	1	20	30	28	18	243	− 81
1911	23	14	73	26	55	16	34	16	...	22	41	8	328	+ 4
Mean	45	44	51	35	24	10	12	6	13	24	25	35	324	

TABLE 11.

Approximate Monthly Duration of Thunderstorms. Deviations from the Normal Monthly Means, in Hours.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1897	− 4	− 5	+ 8	− 1	− 1	− 2	− 2	+ 3	− 3	− 3	−17	−12	−40
1898	+21	− 7	− 7	− 4	+ 2	− 2	− 2	− 1	− 3	0	− 3	+13	+ 6
1899	+ 6	− 3	+11	+ 2	+ 5	+ 1	+10	+ 4	+ 2	− 3	+10	0	+46
1900	− 7	0	+21	+17	− 2	0	+ 2	− 1	− 4	+ 5	− 7	+ 6	+30
1901	− 2	+ 5	+ 8	+ 4	− 2	+ 2	− 2	+ 2	− 1	− 8	−12	+13	+ 7
1902	− 2	+ 3	−15	+ 7	− 2	+ 3	0	+ 1	+14	+ 8	− 6	− 4	+ 8
1903	− 2	+11	−14	+13	0	− 2	− 1	− 1	− 2	0	+ 1	− 1	+ 1
1904	−10	+ 4	−11	− 9	− 1	+ 4	− 1	− 1	− 1	+ 3	+ 9	− 8	−22
1905	+24	+ 1	− 9	+ 2	− 2	− 1	− 2	− 1	+ 1	−11	− 5	+ 2	− 2
1906	−16	− 1	− 7	−10	+ 3	− 2	− 2	− 1	− 4	0	+23	0	−17
1907	+10	+ 9	− 6	− 1	+ 2	− 2	− 2	− 1	+ 4	+ 8	+ 2	− 4	+16
1908	+ 5	− 5	+31	−11	− 2	+ 3	+ 2	0	− 1	−13	+ 7	+ 6	+21
1909	− 5	+ 4	− 8	+ 4	+ 2	− 2	− 2	− 1	− 2	+ 1	− 5	+ 8	− 6
1910	− 2	−11	+ 5	− 8	− 2	+ 1	− 1	− 1	+ 6	+ 6	− 7	−12	−19
1911	−19	− 7	− 9	− 4	+ 2	− 1	+ 5	+ 2	− 4	+ 4	+11	− 7	−27
Mean	23	18	22	11	2	2	2	1	4	13	18	19	136

TABLE 12.

APPROXIMATE MONTHLY DURATION OF LIGHTNING WITHOUT THUNDER. DEVIATIONS FROM THE NORMAL MONTHLY MEANS, IN HOURS.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1897	−25	−25	−12	+ 2	+ 1	− 2	− 1	0	+ 1	− 7	−10	−12	− 90
1898	− 6	−26	+ 5	− 8	+ 4	− 2	− 1	− 1	− 4	−13	+ 8	+ 5	− 41
1899	+14	+ 5	+34	+17	+ 1	− 2	+ 9	+ 7	+ 1	+20	+17	−10	+118
1900	−13	+28	− 6	− 7	− 4	− 1	+ 2	+ 1	− 5	− 9	− 9	+ 3	− 19
1901	+ 8	+ 8	−13	− 8	− 5	− 1	− 1	+ 3	− 1	− 7	+ 1	+14	− 1
1902	− 2	+17	−14	+ 7	− 4	− 1	− 1	− 2	+10	0	−13	−20	− 22
1903	+ 3	+ 7	−17	− 1	+ 1	− 2	0	− 1	− 5	+ 3	− 6	0	− 18
1904	− 1	+18	− 6	−17	− 5	+ 7	− 1	− 2	+ 6	0	− 8	− 7	− 19
1905	+ 4	0	+ 6	+17	0	− 2	− 1	− 2	− 5	−13	− 8	+ 3	+ 1
1906	−10	− 9	+18	− 7	− 1	− 2	− 1	− 2	+ 3	+ 3	+ 4	− 2	− 7
1907	+28	+ 1	+ 3	− 5	+ 9	− 2	− 1	− 2	+ 1	+23	+ 2	+ 4	+ 60
1908	− 7	− 6	− 8	−17	+ 1	0	0	+ 4	+ 7	−13	+ 1	+ 4	− 34
1909	− 3	− 1	+17	+16	+ 2	− 2	− 1	− 2	0	+ 6	+10	+14	+ 57
1910	+15	− 5	+ 3	−14	− 5	+ 7	− 1	− 2	− 4	+ 2	+ 1	+ 3	− 1
1911	− 4	− 9	−10	+26	+ 3	− 2	+ 5	− 1	− 4	+ 3	+ 7	− 6	+ 8
Mean	25	26	28	17	5	2	1	2	5	15	16	22	164

TABLE 13.

MONTHLY TEMPERATURES IN THE SUN. DEVIATIONS FROM THE NORMAL MONTHLY MEANS.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1897	−2·7	+2·3	+0·3	+4·6	+3·6	+0·6	+1·5	+1·5	+1·5	+3·4	+0·1	+2·6	+1·6
1898	−9·6	−6·8	−1·7	+0·1	−2·6	+0·4	−0·1	+2·3	−0·1	−1·2	−0·4	+3·4	−1·4
1899	+1·5	+3·6	−1·1	−4·9	−4·2	+2·0	−4·6	−0·8	+2·0	−3·8	−0·5	+0·3	−0·9
1900	−0·1	+2·0	−1·4	−0·8	+4·2	+0·5	−4·9	−2·8	+5·2	+3·5	+0·9	−4·1	+0·2
1901	+1·7	+1·0	−2·0	+1·7	+0·2	+1·8	+1·6	+3·0	−3·0	−2·8	+0·8	−0·1	+0·3
1902	−4·4	−0·7	−2·2	−0·8	+4·1	−3·7	+2·0	0·0	−5·3	−0·6	−3·7	−4·1	−1·7
1903	−2·6	−0·5	+1·3	−1·3	+0·3	+1·5	+0·1	−0·2	−0·6	−4·5	−3·8	−0·6	−0·9
1904	−3·7	−0·7	−2·6	−1·1	−2·3	−1·0	+0·3	+0·5	+0·7	+1·7	+3·3	−1·9	−0·6
1905	+6·6	+1·3	+2·9	+4·4	+1·0	−2·2	+2·6	0·0	−2·0	+0·2	+1·9	+0·6	+1·4
1906	+0·9	−3·4	−2·9	+0·5	+1·1	+3·0	+3·4	+0·9	+1·3	−2·0	−0·3	−2·0	0·0
1907	+1·3	−2·0	+2·3	−4·5	−6·6	−0·1	+1·1	+3·6	−0·6	−2·4	−1·4	−2·7	−1·0
1908	+1·8	+1·5	+1·1	−4·2	+0·6	−3·1	−2·7	−4·5	−2·5	+1·0	−0·9	0·0	−1·0
1909	+5·2	−0·3	+3·3	+3·1	+2·8	+3·5	+4·7	+3·4	+4·4	+4·1	+5·1	+2·7	+3·5
1910	+3·5	+0·6	+6·1	+4·7	+3·9	+0·1	−1·8	−0·2	+0·7	+1·0	−0·7	+2·4	+1·7
1911	+1·1	+2·6	−3·3	−1·8	−6·8	−3·5	−2·8	−6·1	−1·6	+2·2	−0·1	+3·5	−1·4
Mean	153·3	152·6	144·8	135·5	124·9	118·4	119·4	126·9	136·3	142·5	149·7	153·7	138·2

TABLE 14.

MONTHLY MAXIMUM TEMPERATURES IN THE SHADE. DEVIATIONS FROM THE NORMAL MONTHLY MEANS.

Year.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1897	−3·9	+3·3	+0·6	+6·4	+2·4	+0·5	+1·7	+2·0	+0·1	+3·8	+0·3	+2·1	+1·6
1898	−5·6	−5·0	+2·3	+0·2	−2·6	+0·8	−0·3	+1·5	0·0	−1 6	+2·6	+2·5	−0·4
1899	+2·3	+5·1	+0·3	−3·2	−5·3	+0·3	−3·7	+1·0	+4·1	−0·3	−0·5	+1·5	+0·2
1900	+1·7	+5·3	+2·0	+1·1	+5·5	+1·1	−2·5	−1·9	+6·0	+1·7	+2·1	−3·9	+1·6
1901	+2·6	+0·6	−1·7	+1·0	−0·4	+0·8	−0·1	+2·5	−4·4	−3·0	−0·3	−0·1	−0·2
1902	−1·7	0·0	−1·4	−0·7	+4·8	−1·4	+2·5	0·0	−5·9	+0·1	−1·8	+1·8	−0·3
1903	+2·9	+1·5	+2·9	−1·7	−0·1	−0·7	+1·3	+0·6	+1·0	+0·2	−0·2	+1·3	+0·8
1904	−2·9	−1·8	−1·6	+1·9	+0 9	+0·9	+1·6	+0·2	−1·7	+0·3	+2·2	−3·7	−0·3
1905	+2·8	−1·1	+0·5	+2·8	+1·8	−1·5	+2·9	−1·7	−1·4	+3·8	+0·8	+0·5	+0·9
1906	+2 1	−2·0	−1·3	−0·1	+0·7	+1·2	+0·5	−2·0	+1·4	−3·0	−2·4	−2·6	−0·6
1907	−1·9	−2·8	+0·5	−4·4	−4·8	+0·9	−0·2	+2·3	−1·0	−2·0	−1·3	−3·6	−1·5
1908	+1·3	+2·8	+1·9	−4·2	+3·0	+0·6	−1·0	−0·4	+1·0	−0·1	+0·1	+0·4	+0·5
1909	−1·0	−5·6	−3·3	−1·0	−2·7	+2·0	0·0	+0·7	+0·4	−0·7	+2·3	−2·2	−0·9
1910	+0·8	−2·6	+1·0	+2·7	+2·1	−1·5	−1·0	−0·8	0·0	−2·4	−3·4	+1·1	−0·3
1911	+1·1	+3·0	−2·2	−1·0	−5·3	−3·6	−2·4	−3·4	0·0	+2·8	−0·4	+5·6	−0·5
Mean	88·8	88·0	82·9	77·0	70·1	64·7	65·9	71·0	78·0	81·5	86·1	89·6	78·6

TABLE 15.

Monthly Minimum Temperatures in the Shade. Deviations from the Normal Monthly Means.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1897	−2·1	−1·2	−1·1	+3·7	+1·7	−1·3	−0·5	+1·3	−2·4	+1·4	−3·2	+1·5	−0·2
1898	+0·8	−2·2	−0·2	−1·2	+0·6	−2·0	−3·1	−0·4	−3·6	−2·7	+2·0	+0·3	−0·9
1899	−0·1	+2·0	+2·0	+1·0	−1·7	+0·1	+2·3	+2·8	+3·4	+1·3	+0·4	+0·3	+1·2
1900	−0·1	+1·1	+2·0	+3·6	+2·7	+2·8	+2·4	−0·8	+1·9	−0·5	+0·3	−0·6	+1·3
1901	−0·3	+1·5	+0·4	+3·3	−3·0	+2·1	−2·6	+2·5	+0·5	+0·8	−0·2	+0·8	+0·5
1902	−1·9	−0·1	−1·2	−2·4	+0·7	−1·8	−0·2	−0·3	−1·4	+0·8	−3·3	+0·1	−0·9
1903	−0·4	+1·0	−3·0	−3·1	−1·5	−3·0	−0·4	+0·3	−0·7	−2·0	−2·0	+1·5	−1·1
1904	+0·5	−1·4	+0·8	−1·5	−1·7	+0·1	+0·1	−1·4	−1·4	−0·3	+0·8	−3·6	−0·7
1905	−0·1	+0·3	−0·9	+2·8	−0·6	−1·7	+1·8	−1·4	+0·1	+0·7	+2·2	+2·3	+0·5
1906	+2·4	−1·0	−1·2	−3·2	+1·2	+1·0	−1·5	−4·7	+0·2	−0·9	+3·1	−1·6	−0·5
1907	+0·5	0·0	+1·7	+1·5	−0·1	+1·5	−0·4	−0·4	+1·6	−0·3	−1·9	−1·7	+0·2
1908	−2·4	+0·3	−1·9	−6·6	−0·4	−1·0	+1·9	+1·6	+2·1	−1·0	+0·3	+0·9	−0·5
1909	+2·1	+0·4	−0·3	+2·3	+1·9	+3·7	+0·8	+0·3	+0·8	−1·2	+0·6	−0·4	+0·9
1910	+0·3	−0·5	+2·2	−0·1	−0·2	−1·4	0·0	−0·7	−0·1	+0·1	−2·2	−1·2	−0·3
1911	+0·9	+0·3	+0·3	−0·4	+0·9	+0·3	+0·1	+0·9	−1·3	+3·1	+3·7	+1·5	+0·9
Mean	61·6	61·2	57·4	50·4	42·1	36·1	35·8	38·9	45·8	50·9	54·9	60·4	49·6

TABLE 16.

Monthly Minimum Radiation Temperatures at a Height of Five Inches above the Grass. Deviations from the Normal Monthly Means.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1897	−2·2	−1·9	−1·5	+3·3	+1·1	−1·1	−1·0	+1·8	−2·5	+1·3	−4·0	+1·7	−0·4
1898	+1·9	−2·0	−0·5	−1·4	+0·9	−2·0	−3·5	−0·1	−2·9	−1·9	+3·0	+1·0	−0·6
1899	+0·8	+2·2	+3·3	+2·4	−0·6	+1·3	+4·5	+4·3	+4·1	+2·7	+2·2	+1·7	+2·4
1900	+0·3	+1·1	+2·5	+4·5	+3·4	+3·9	+4·2	+0·6	(+2·2)	+0·9	+1·5	+0·8	+2·2
1901	−0·9	+1·9	+1·4	+4·2	−3·0	+2·8	−2·6	+2·4	+1·4	+1·1	−1·0	+0·8	+0·7
1902	−2·0	−0·1	−1·2	−2·4	−0·3	−1·4	+0·1	+0·1	−0·6	+1·1	−3·9	+0·2	−0·8
1903	−0·5	+1·3	−4·3	−3·4	−1·5	−3·4	−1·0	+0·2	−1·5	−2·5	−2·3	+1·0	−1·5
1904	+1·3	−1·5	+1·1	−2·1	−2·3	+0·3	−0·4	−1·9	−1·5	−0·6	+0·6	−4·8	−1·0
1905	−1·3	−0·3	−1·5	+1·7	−1·1	−1·7	+1·0	−1·9	+0·3	−0·3	+2·7	+2·7	0·0
1906	+2·7	−1·2	−0·7	−3·8	+1·2	+0·9	−2·6	−5·9	−0·6	−1·4	+3·8	−1·7	−0·8
1907	+0·8	+0·3	+1·6	+3·1	+0·8	+1·2	−0·8	−1·8	+2·1	+0·1	−2·8	−1·9	+0·2
1908	−2·7	+0·4	−2·2	−7·0	−1·2	−1·2	+2·4	+1·9	+2·0	−1·8	+0·5	+1·2	−0·6
1909	+2·4	+1·2	−0·3	+2·7	+2·1	+2·9	−0·3	0·0	+0·5	−2·2	−0·4	−0·8	+0·7
1910	−0·2	−0·6	+1·6	−1·5	−1·3	−2·1	−0·3	−0·7	−0·2	+0·4	−2·9	−1·7	−0·8
1911	+0·1	−0·8	+0·5	0·0	+1·5	+0·3	+0·5	+1·2	−2·6	+2·6	+3·4	−0·7	+0·5
Mean	57·6	57·4	53·6	45·9	37·5	31·1	30·7	34·0	41·2	46·3	50·0	56·1	45·1

TABLE 17.

Monthly Mean Temperatures of the Dry Bulb. Deviations from the Normal Monthly Means.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1897	−3·4	+1·3	0·0	+5·3	+2·4	−0·7	+0·4	+1·6	−1·2	+2·3	−0·9	+1·3	+0·8
1898	−3·0	−4·0	+0·8	−0 6	−1·2	−0·4	−1·9	+0·3	−1·5	−1·8	+1·9	+1·3	−0·8
1899	+0·8	+3·7	+0·6	−1·4	−3·5	+0·3	−0·2	+1·9	+3·3	+0·5	−1·0	+0·4	+0·4
1900	+0·2	+3·0	+1·5	+2·0	+3·6	+1·8	+0·2	−1·3	+3·9	+0·7	+1·5	−2·9	+1·2
1901	+1·3	+0·8	−1·1	+2·0	−1·7	+1·4	−1·6	+2·0	−2·2	−1·7	+0·1	+0·1	−0·1
1902	−1·5	−0·3	−1·1	−1·8	+2·4	−1·8	+0·8	0·0	−4·1	+0·3	−2·1	+1·3	−0·7
1903	+2·2	+0·9	+0·6	−2·3	−0·9	−2·0	+0·1	+0 6	+0·3	−0·7	−0·6	+0·9	−0·1
1904	−1·6	−2·2	−0·6	+0·6	−0·5	+0·4	+0·7	−0·7	−1·0	+0·2	+1·7	−3·1	−0·5
1905	+1·2	−0·6	−0·3	+2·7	+0·6	−1·5	+2·2	−1·5	−0·6	+2·4	+1·5	+1·2	+0·6
1906	+2·3	−1·1	−0·9	−1·3	+1·0	+1·2	−0·7	−3·3	+0·8	−1·8	−0·5	−2·4	−0·6
1907	−0·9	−1·7	+0·7	−1·8	−2·6	+1·1	−0·1	+0·8	+0·1	−1·4	−1·6	−2·9	−0·9
1908	−0·2	+1·8	+0·4	−4·9	+1·4	0·0	+0·5	+0·7	+1·6	−0·3	+0·1	+1·1	+0·2
1909	+0·2	−2·8	−2·0	+0·6	−0·2	+3·0	+0·7	+0·6	+0·9	−0·6	+2·1	−1·4	+0·1
1910	+0·8	−1·3	+1·8	+1·5	+0·7	−1·0	−0·1	−0·2	−0·1	−1·6	−3·0	+0·2	−0·2
1911	+1·6	+1·9	−0·8	−0·7	−2·0	−1·5	−0·9	−1·2	−0·4	+2·8	+1·2	+4·6	+0·4
Mean	74·4	73·5	69·0	62·5	54·8	48·8	49·3	53·9	61·2	65·9	70·4	74·7	63·2

TABLE 18.

MONTHLY MEAN TEMPERATURES OF THE DEW-POINT. DEVIATIONS FROM THE NORMAL MONTHLY MEANS.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1897	+3·4	−1·6	−0·9	+1·6	+0·3	−0·7	+0·2	+0·9	−3·3	−0·2	−6·8	−0·3	−0·4
1898	+6·8	0·0	+0·6	−0·9	+1·5	−2·8	−4·5	−0·2	−3·7	−1·4	+2·9	−0·1	−0·2
1899	−1·1	−2·2	+3·8	+4·0	+1·3	+1·4	+5·8	+4·5	+2·0	+3·6	+2·4	+0·2	+2·1
1900	−0·8	−2·4	+3·2	+5·4	+2·0	+2·5	+5·3	+1·0	−0·2	−1·7	−1·3	+4·4	+1·4
1901	−4·5	+1·6	+3·1	+5·1	−3·4	+1·1	−3·1	+1·7	+4·2	+4·3	−0·2	+3·3	+1·1
1902	−1·5	+1·0	−0·6	−1·3	−1·1	−0·6	+0·3	+0·1	+3·5	+1·2	−3·0	0·0	−0·2
1903	−4·3	+0·5	−8·7	−2·9	−1·1	−3·5	−1·5	0·0	−2·7	−3·7	−2·1	+0·6	−2·5
1904	+3·1	0·0	+2·4	−4·1	−2·9	−0·3	−1·8	−2·2	−2·4	−0·2	−0·3	−4·8	−1·2
1905	−1·1	+0·4	−1·9	+1·8	−3·3	−0·9	−0·9	−1·8	+0·8	−3·4	+3·2	+1·0	−0·5
1906	+1·5	−0·5	−2·3	−5·2	+0·9	−0·6	−3·9	−5·4	−2·0	0·0	+4·5	−0·3	−1·1
1907	+1·8	+3·5	+1·3	+4·1	+2·8	+0·5	−1·5	−2·4	+2·7	+0·9	−1·0	+2·7	+1·2
1908	−5·2	−1·6	−5·5	−8·2	−2·5	−2·6	+2·2	+2·4	+1·9	−2·5	−1·0	+0·9	−1·8
1909	+4·5	+4·8	+2·1	+3·8	+4·3	+4·8	+1·0	−0·4	+2·0	−1·9	−1·9	+0·4	+1·9
1910	−1·1	+0·6	+2·2	−3·4	−2·1	−0·5	+0·8	−1·2	+0·2	+2·8	−0·6	−3·2	−0·5
1911	−2·2	−3·9	+0·8	−0·4	+3·7	+2·4	+1·9	+3·3	−2·7	+2·3	+5·0	−4·5	+0·4
Mean	52·3	53·3	52·5	47·0	39·1	34·2	32·9	33·3	37·3	41·0	43·3	48·2	42·9

TABLE 19

MONTHLY MEAN PERCENTAGES OF RELATIVE HUMIDITY. DEVIATIONS FROM THE NORMAL MONTHLY MEANS.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1897.........	+11·5	− 5·6	− 1·3	− 7·2	− 4·7	−0·4	0·0	−1·8	− 4·2	−3·8	−9·5	− 2·2	−2·3
1898.........	+17·8	+ 6·5	− 0·5	− 1·2	+ 5·9	−6·0	− 6·2	−0·6	− 4·3	+0·5	+2·2	− 1·9	+1·0
1899.........	− 1·7	− 9·0	+ 6·3	+11·9	+ 9·5	+2·8	+14·3	+5·7	− 2·4	+5·9	+5·4	− 0·5	+4·0
1900.........	− 1·6	− 8·4	+ 3·8	+ 7·7	− 3·5	+2·0	+12·0	+4·4	− 6·2	−3·5	−3·5	+11·8	+1·2
1901.........	−10·0	+ 1·2	+ 8·5	+ 6·4	− 4·6	−1·3	− 3·7	−0·1	+11·7	+9·8	−1·3	+ 4·6	+1·7
1902.........	− 0·1	+ 1·6	+ 0·3	+ 1·3	− 7·4	+3·3	− 0·8	0·0	+13·3	+1·0	−2·4	− 1·3	+0·7
1903.........	−10·2	− 1·2	−17·6	− 1·7	− 0·1	−3·7	− 4·1	−1·5	− 5·7	−5·1	−2·0	− 0·9	−4·5
1904.........	+ 7·7	+ 3·7	+ 5·6	− 9·6	− 5·8	−1·5	− 5·9	−3·2	− 3·6	−1·1	−2·5	− 3·4	−1·7
1905.........	− 4·1	+ 1·9	− 2·8	− 1·8	− 7·8	+1·7	− 6·9	−1·4	+ 3·0	−9·0	+3·0	− 0·4	−2·1
1906.........	− 1·4	0·0	− 3·0	− 8·1	0·0	−3·8	− 7·5	−5·2	− 5·2	+2·7	+8·5	+ 2·4	−1·8
1907.........	+ 3·7	+ 8·4	+ 1·5	+12·7	+11·3	−1·7	− 3·9	−6·5	+ 4·6	+2·8	+1·0	+ 8·1	+3·5
1908.........	− 8·4	− 5·9	−10·9	− 7·4	− 8·3	−6·3	+ 4·1	+4·0	+ 0·9	−3·2	−2·6	0·0	−3·7
1909.........	+ 7·0	+14·2	+ 7·5	+ 6·7	+ 9·7	+4·2	+ 0·3	−1·4	+ 2·0	−3·5	−5·8	+ 1·0	+3·5
1910.........	− 3·0	+ 2·2	− 0·1	−10·2	− 6·6	+0·8	+ 1·8	−2·5	+ 0·6	+7·1	+2·5	− 5·5	−1·1
1911.........	− 6·8	−10·3	+ 3·1	+10·1	+12·6	+9·2	+ 6·2	+9·5	− 4·7	−0·2	+6·3	−12·5	+1·0
Mean	51·2	54·3	60·4	60·9	59·3	60·1	56·3	48·9	44·9	44·6	42·1	44·1	52·3%

TABLE 20.

ANNUAL RAINFALL.

Year.	Kimberley.	Year.	Kenilworth.
	Inches.		Inches.
1877	13·58	1894	24·51
8	9·34	5	15·60
9	19·38	6	21·07
1880	15·43	7	8·85
1	30·30	8	18·29
2	14·77	9	19·39
3	11·21	1900	18·78
4	18·43	1	22·23
5	9·63	2	22·25
6	14·44	3	12·25
7	18·74	4	17·64
8	17·34	5	14·02
9	17·49	6	17·89
1890	23·11	7	24·74
1	31·30	8	12·92
2	12·88	9	20·39
3	16·25	1910	15·44
4	25·03	1	13·10
5	15·98		
6	19·86		

CONTRIBUTIONS TO A KNOWLEDGE OF SOUTH AFRICAN OLIGOCHAETA.—Part I.

ON A PHREODRILID FROM STELLENBOSCH MOUNTAIN.

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(Received October 9, 1912.)

(Read October 16, 1912.)

Pls. XI.–XIII.

The present paper deals with the anatomy of the reproductive system and the externals of a new Phreodrilid genus taken on the Stellenbosch Mountains during September, 1910.

This constitutes the first record of any representative of the family in Africa ; but at the same time the occurrence is not surprising, but rather expected, since representatives are found in all the other land masses of the Southern Hemisphere, including Kerguelen Island, which lie south of the parallel 30° S. We refer later to the significance of this distribution.

Several other essays during different times of the year both on the Stellenbosch Mountains and Table Mountain had proved fruitless in discovering either the same or different forms, since the first success ; and this was explained tentatively by us in a paper recently read before the South African Association for the Advancement of Science as being probably due to the fact that the worms mature during the spring and that they disappear from the pools during the hotter months of the year.

This explanation has been verified by the discovery of large numbers of another representative on Table Mountain during the past week.

Preliminarily we may note that the circumpolar distribution of the family is now complete, and we do not hesitate to remark that a detailed survey of the mountains above 3,000 feet and flanking the southern limits of the Karroo will furnish still many representatives of the family.

Not only does the new genus described herein prove interesting zoogeographically, but also is of important phylogenetic interest in explaining the spermathecal and male reproductive apparatus of such forms as Phreodriloides described by Benham from Mt. Koscisuko, New South Wales, and of a form described by one of us (E. J. G.) from Mt.

Wellington, Tasmania, but which was immature and in many ways so aberrant in regard to the spermathecal apparatus that it was deemed wise at the time of publication not to burden literature of the group with another new generic name.

There is now, however, no doubt but that the Tasmanian form constitutes a distinct genus for which the name Tasmaniaedrilus is now proposed—*T. tasmaniaensis.*

In view of the special distributional interest in the form under description, we propose the title *Gondwanaedrilus africanus* (gen. et sp. nov.).

GONDWANAEDRILUS, gen. nov.

Elongate body; ventral setae paired, one sigmoid, slender and simple, the other more markedly sigmoid, stouter, bifid; male pore in xii., female pore opening with male pore (?); spermathecal pores absent, spermathecal ducts opening into part of male apparatus.

Gondwanaedrilus africanus (gen. et sp. nov.).

Numerous individuals were obtained in a ditch on the plateau on Stellenbosch Mountain in association with Gammarus (an Amphipod), and Moss. No other vermian or invertebrate life was represented, and experience with the habitats of Phreodrilidae in Africa and other parts indicates that this fact has in all probability a marked significance, which we discuss later.

The individuals collected have an average dimension as follows :—

Length 20–22 mm.

Breadth ·8–1·0 mm.

Setae.—Each ventro-lateral group consists of two setae. One of these is slightly shorter, stouter, and more intensely sigmoid than the other; possesses a distinct modulus, and is strongly bifid at the free extremity. The other seta in each of these bundles has a simple pointed extremity.

The dorsal setae are exceedingly long, and capilliform with a distinct sigmoid yet faint curve. Each bundle carries three such setae. These setae are so easily broken in mounted and also preserved specimens that it is difficult in many cases to make out their distribution. However, they were traced forwards as far as segment iii.

Clitellum.—This structure extends through segments xii, xiii, and xiv.

In this paper we deal only with the Reproductive System, which constitutes the essential generic system in the group, for variation.

In all the specimens examined both ova and spermatozoa are abundant, indicating that fertilisation must take place during the spring.

The position of the gonads cannot be definitely stated, but can, at least in the case of the testes, be inferred within safe measures.

The male pores, as previously indicated, lie on each ventro-lateral region of segment xii.

The female pore could not be clearly made out, but observations suggest that in all probability it opens in common with the male pore, or, rather, immediately behind it.

In segments x, xi, there is a large median mass of developing spermatozoa, but no traces of masses of mature elements. Similarly there is an absence of such in the spermathecae, indicating that the breeding-time has not been reached.

The masses of spermatozoa in x, xi, resembling in position similar masses in Phreodrilidae, may be taken as indicating that the testes occupy the position usual in other genera.

Further, the funnel of the spermduct opens into xi. Masses of ova were found in xiv, xv. These clumps appear to be in close apposition and relation ? with the blood vascular system.

The spermathecae are paired structures situated in xiv immediately latero-dorsal to the alimentary canal. In longitudinal section each is elliptical. From the antero-ventral or ventral side the spermathecal duct passes down towards the ventral surface behind the septum separating xiii, and xiv. This duct instead of leading into the spermathecal chamber so that its wall becomes directly confluent with that of the chamber, becomes thickened so that its lumen communicates with that of the chamber at the summit of a large papilla which projects into the interior of the spermatheca.

The spermathecal duct on nearing the ventral surface pierces the septum and passes forwards into xiii. After a slightly tortuous course it then ascends obliquely and forwards to open into the posterior end of a cylindrical chamber, which is an extension backwards and dorsally from the penial chamber.

The most noteworthy feature about the spermathecae is the marked thinness of the wall, at least in part, when compared with the wall of the corresponding chamber in other genera such as Phreodrilus and Astacopsidrilus. The posterior and dorsal wall is so thin and indistinct in our specimens that it is difficult, except that assistance is rendered by the thicker anterior and ventral part of the wall, to make out histological details.

On first examination we were struck with the great resemblance between the wall of the spermatheca in part, and the inter-segmental septa, which suggested that these chambers were of the same nature and origin as those found in Eudrilidae.

The histology of the wall is better understood by a study of the spermathecal duct. The wall of this tube is composed of three layers :—

(*a*) The lining layer consists of large cuneate cells bounding a central lumen, with granular protoplasm and a large basally situated nucleus.

(*b*) As in the case of the spermathecal ducts in Astacopsidrilus, &c., there is a well-developed circular musculature.

(*c*) The outermost layer, which is greatly exaggerated in the figure, consists of a flattened and indistinct coelomic epithelium.

The duct on approaching the spermatheca becomes confluent at first with a horn given off from the antero-ventral portion of the spermathecal chamber. It pushes itself into the ventral side of this horn as represented in the figures so that it and the crescentic horn become encased in a common circular musculature. Eventually the duct becomes free in the cavity of the horn, but is now devoid of a musculature, consisting solely of cuneate granular cells. It ceases at the line of junction between the horn and main part of the spermatheca.

The horn thus envelops the duct as a sheath.

The wall of the horn consists of a lining layer of epithelial cells which are loosely arranged, pyriform or lobose, and a distinct outer circular musculature which is confluent with that of the spermathecal duct.

The epithelium of large lobose cells is continued over the interior of the anterior and ventral wall of the main part of the spermatheca. These cells are very large at the commencement of the spermatheca.

This strong epithelium withers away posteriorly, especially along the dorsal wall of the chamber, to such an extent that with a fairly high objective it is difficult to decipher whether this very thin dorsal wall is constituted by a very much flattened epithelium or by a basement membrane from which the epithelial cells found in the anterior and ventral regions have dropped away. This latter idea is suggested by the loose nature of the large lobate cells in the anterior region of the sac and in the horn of the same, and would seem to be the most satisfactory way of explaining the histological differences between the different regions of the spermatheca, and between the spermatheca in part in Gondwanaedrilus and that of other Phreodrilidae such as Phreodrilus and Astacopsidrilus.

The circular musculature found external to the epithelium of the spermathecal duct and spermathecal horn extends for a very short distance external to the epithelium of the anterior part of the chamber, but soon dies out.

In this region also both dorsally and ventrally there are the remains of a loose epithelium, represented by pear-shaped cells, isolated, and much smaller than the lining epithelial cells.

The spermiducal gland is a sigmoid structure, being made up by an axial portion directed antero-dorsally and postero-ventrally, an anterior part running ventrally from the anterior extremity of this, and an ascending posterior portion. The anterior descending moiety lies immediately behind the septum separating xi and xii.

The sperm duct leads backwards from the funnel through the septum xi, xii, and becomes intricately coiled ventrally to the anterior limb and axis of the spermiducal gland. It then passes upwards and backwards to open into the extremity of the posterior ascending part of the spermiducal gland.

The penis projects for some distance into the ventral moiety of the large chamber into which the male pore leads, and its cavity eventually opens into the same.

The large chamber consists of a vertical half which is definitely marked off from a posterior portion which lies behind the entrance of the penis, and with the exception of its anterior extremity lies horizontally. This posterior portion lies partly in segments xii and xiii, and receives at its free posterior extremity the spermathecal duct.

The penis is an elongate pear-shaped structure, its basal portion being attached to the anterior or antero-dorsal wall of the large sac into which the male pore opens. The attachment lies just where the posterior moiety of this sac passes backwards, and this gives at once the impression that this posterior part is of the nature of a diverticulum from the vertical portion which leads to the exterior.

The penis resembles histologically that of Astacopsidrilus in the main, but the chitinous band external to the lining epithelium is absent.

The wall of the penis is composed of three layers :—

(*a*) The inner epithelium is composed of large cells, with markedly granular protoplasm, and with a large spherical nucleus situated towards the base.

(*b*) The middle layer of muscle fibres becomes gradually thicker towards the base of the penis where it reaches its maximum. The area occupied by the musculature is very spongy in the basal region, but this may be due to post-mortem changes or imperfect preservation.

(*c*) The outermost layer is composed of epithelial cells which become much more important gradually from the apex to the base of the penis. Except in the immediate region of the apex of the penis this outer layer is heavily folded, and resembles both in this respect and in the nature of its component cells the lining layer of the sac into which the penis protrudes.

The large sac into which the male pore leads and which contains the penis has a wall composed of three elements :—

(*a*) The inner epithelium is heavily folded, and projects into the lumen of the sac in the form of large blunt villi. Each villus is composed of a number of small squarish cells with a centrally situated nucleus. Into the heart of each villus there project muscle fibres which externally mingle with those of the second layer.

(*b*) The middle layer is composed of muscle fibres, oblique and circular in direction.

(*c*) The outermost layer is composed of loose parenchyma-like cells which in places are very indistinctly made out. This is in all probability due to the state of preservation.

The only other member of the Phreodrilidæ possessing any structure resembling this sac is Phreodriloides, where we find a chamber into which the male pore and the spermduct lead.

This structure has until now been imperfectly understood, since the absence of true spermathecae in Phreodriloides raised special difficulties. Benham termed it tentatively an "autospermatheca," or, at least, regarded the portion lying behind the entrance of the spermduct as corresponding to a specially developed spermathecal apparatus, rather than that the spermathecal pore had moved forwards and become coincident with the male pore.

There can be no doubt that in the rejection of the latter explanation Benham was quite correct.

The anatomy and histology of the form under description show clearly that the large chamber is nothing more than the greatly enlarged penial sheath. Its histology is fundamentally similar to the normal penial sheath of such forms as Astacopsidrilus and its relation to the penis corroborates this idea.

The "muscular sac" of Phreodriloides is undoubtedly the homologue of the posterior horizontal portion of this sac in Gondwanaedrilus, and both of these structures are posterior outgrowths of the penial sheath. The so-called penial chamber of Phreodriloides and the "muscular sac" have become differentiated histologically along different lines, the former becoming in part glandular, the latter becoming heavily muscularised. Both, however, represent portions, ventral and dorsal respectively, of the large sac of Gondwanaedrilus.

A glance at the figures of this structure in both genera will quickly convince one of the homology.

Anatomically, special interest centres round the spermathecae and male reproductive apparatus since we now have a definite explanation of the peculiar modification of these in Phreodriloides.

In order to make this perfectly clear we will orient ourselves by taking in assumption as normal the condition of these organs in Phreodrilus.

In this genus the spermathecae are well-developed paired structures opening independently to the exterior, and provided with a strong definite granular and glandular epithelium. This applies to all the species of the genus.

In Astacopsidrilus the spermathecae may remain separate or may communicate with each other, but the walls retain the same nature of that of Phreodrilus. In this genus, however, a most important modification is wrought in that the spermathecal ducts open, not to the exterior, but into a thin-walled sac—an ovisac—from which the oviduct leads definitely to the exterior, opening in the position or segment characteristic of Phreodrilus. The structure of the spermiducal gland and male apparatus resembles fundamentally that of Phreodrilus. The communication between such a "true" spermatheca and the female duct is unique.

In Gondwanaedrilus we find definite paired spermathecae which occupy the typical position but which communicate with the male chamber. This is an exceedingly interesting counter-condition to that in Astacopsidrilus.

As has been pointed out previously in this paper in considering the structure and histology of this organ its wall differs very much from that of Phreodrilus and Astacopsidrilus. The thinness of the wall posteriorly suggests at first that here the spermathecae are of the same nature and origin as in the Eudrilidae. This view we cannot accept, however, since the antero-ventral portion of each chamber near its junction with the spermathecal duct is lined with thick pear-shaped cells recalling similar cells in connection with the spermiducal glands to which histologically there is a general resemblance in Oligochaeta in general. The significance and importance of this view will be seen when considering Phreodriloides.

Lastly, the extension of the penial chamber upwards and backwards beyond the entrance of the penis to meet the spermathecal duct is important since this extension undoubtedly represents the muscular sac or "autospermatheca" of Phreodriloides.

In Tasmaniaedrilus one of us (E. J. G.) noted a series of unpaired and disconnected chambers with thin walls, and recognised such as the remains of spermathecal structures. The structure of the wall in the spermathecae of Gondwanaedrilus no longer leaves doubt concerning the correctness of this view. In all probability in Tasmaniaedrilus we see the remains of an evanescent spermatheca devoid of ducts.

In Phreodriloides it is now perfectly clear that the true spermathecæ have disappeared, and that the so-called "autospermatheca" corresponds to the extension of the penial chamber in Gondwanaedrilus.

The various modifications of the spermathecae are shown in the table below:—

Phreodrilus	Spermathecae and pores distinct. Wall distinctly glandular.
Astacopsidrilus	Spermathecae distinct, but ducts communicating with female duct. Wall distinctly glandular.

Gondwanaedrilus	Spermathecae distinct, but ducts communicating with male penial chamber.
Tasmaniaedrilus	Spermathecae evanescent and ducts absent. Wall thin and non-glandular.
Phreodriloides	Spermathecae and ducts absent.

It will be seen that we have now an undoubtedly complete anatomical series, and that the family which at first known only by the genus Phreodrilus was considered so unique in regard chiefly to its setae and spermathecae, can be split into genera whose most marked differential characters concern both these structures.

Again, it is quite clear that Phreodrilus with its well-developed spermiducal gland, glandular spermatheca, and spermathecal ducts opening directly to the exterior, approaches more closely than any of the other genera to the ancestral Phreodrilid stock.

Remarks.

The distribution of the family has been very interesting up to the present time in view of the limitation to the southern portion of the Southern Hemisphere, and also of its restricted habitat in these regions.

That the group does possess a great phylogenetic value will, we think, be conceded by all workers on the Oligochaeta, and the fact that their occurrence in South Africa and further in the mountainous region only was deduced by one of us several years ago is, at least, not inconsistent with this idea.

The fact that the well-searched parts of the Northern Hemisphere where under varied bathymetrical conditions the Oligochaetan fauna has been well investigated by many of the foremost workers on the group, have not revealed any Phreodrilid representatives—and the same applies in the case of the tropics—may very reasonably be interpreted as indicating the restriction of the family to the area including the various parts where they are now known to occur.

In a previous paper it was noted by one of us that the habitat appealed in its peculiar conditions as a significant fact.

All the Phreodrilidae yet discovered and described are inhabitants of cold areas, with the exception of Astacopsidrilus which, however, can be neglected here since its peculiar external appearance bound up with its unique association with the Crayfish—Astacopsis—makes it appear as being *sui generis*, and explains its bathymetrical and exceptional distribution. The various forms, if not inhabiting areas with a constant low temperature as in the Falkland Islands, occur on mountains exceeding easily 3,000 feet, and we now know that the worms appear in the pools only during the colder seasons of the year.

These remarks may be construed as signifying one of two conclusions :—

(*a*) The living Phreodrilidae are the descendants of an old cold climate ancestral stock which once inhabited the southern lands, and are now restricted to areas where these conditions are now attained; or—

(*b*) The Phreodrilidae are the remnants of a stock which has been unable to meet the demands for existence under normal and temperate conditions, and consequently have taken up an abode in places where the struggle for existence is far less keen.

Before discussing these conclusions we will mention several facts which will tend to make the issue more easily understood.

Firstly, the Phreodrilidae undoubtedly show marked affinities, when phylogenetically considered, with the Lumbriculidae, and the latter are as truly restricted to the Northern, as the former to the Southern Hemisphere.

Secondly, it would appear that the Phreodrilidae are not capable of transmigration across sea barriers, as are so many of the terrestrial Oligochaeta. They do not meet with the same chances of migration at the hands of man like many terrestrial Oligochaeta—a fact which is explained by their habitat, and that the chief medium serving for conveyance in the hands of man is either soil or water; and which is supported by the absence of Phreodrilidae except in the restricted habitats mentioned above, and by the fact that as yet no species is known as being common to any two of the land areas where the family is represented. In this connection we cannot but point out that in no division of the Invertebrata are the species more valid since they are framed without exception not only on exceedingly well-marked external differences in connection with setae, etc., but also on peculiarly accentuated internal differences. There is no room for synonymy in any of the group.

The restriction of the family to the Southern Hemisphere certainly finds its parallel in the case of many other groups, but it would seem that no explanation other than that of the existence at one time of a direct connection between the continents of the Southern Hemisphere is satisfactory. The Lumbriculidae which occupy a corresponding phylogenetic importance are as truly restricted to the Northern Hemisphere, and thus we are led to conclude that each group has been evolved in the respective hemispheres. This being the case, we must then regard the existing members of the family as the descendants of an ancient Phreodrilid ancestor which may have flourished as early as, if not earlier than, Permo-Carboniferous times on ancient Gondwanaland.

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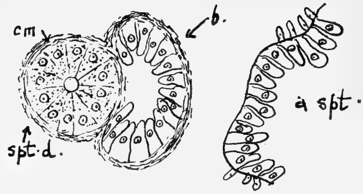

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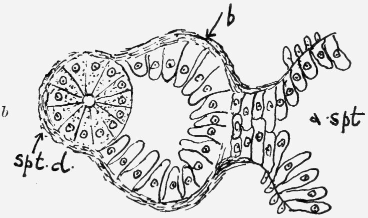

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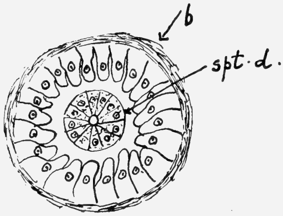

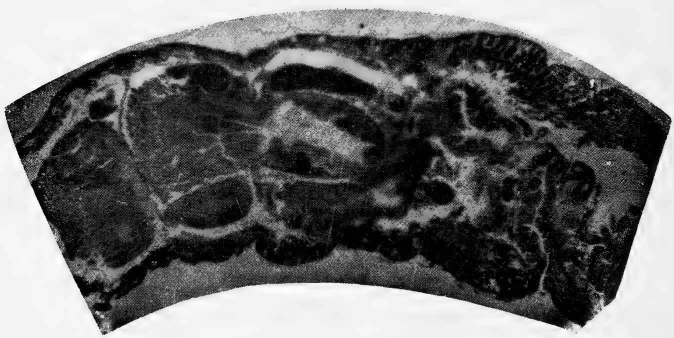

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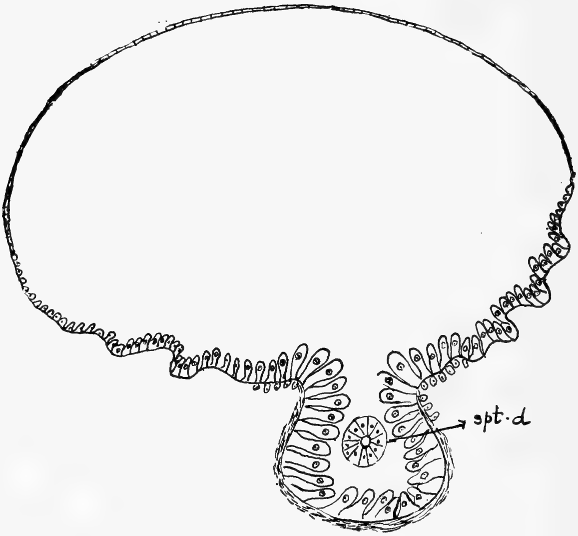
SOUTH AFRICAN OLIGOCHÆTA.



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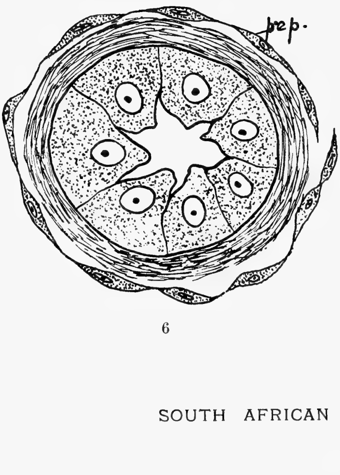

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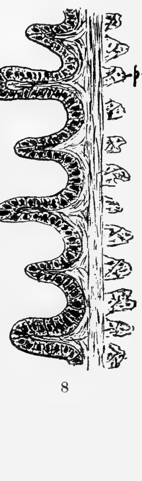

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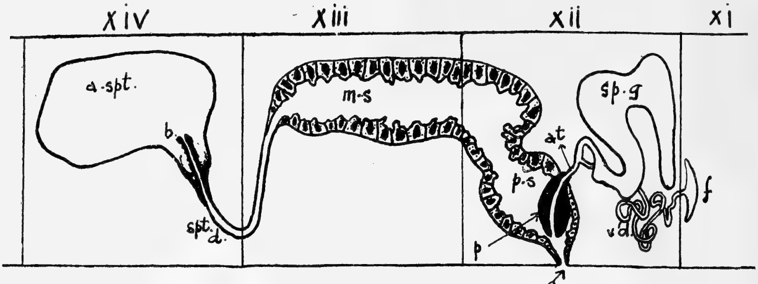

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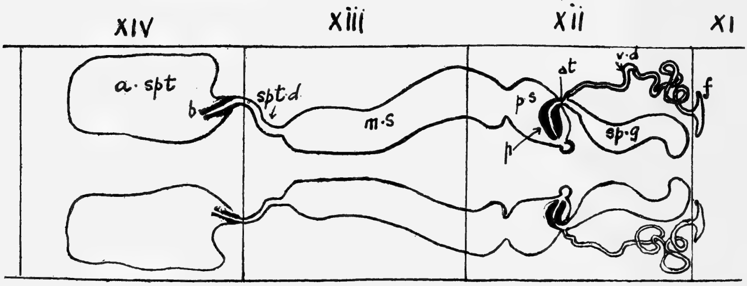

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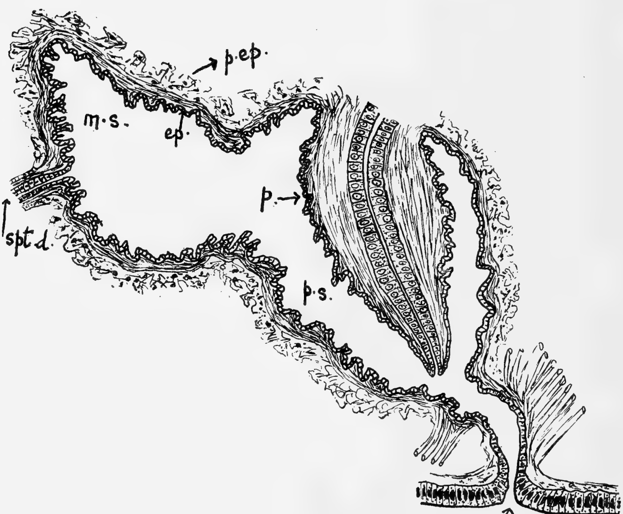

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SOUTH AFRICAN OLIGOCHÆTA.

EXPLANATION OF PLATES XI.–XIII.

a.spt = ampulla of spermatheca.
at = atrium.
b = bulb of spermatheca.
ep = internal epithelium.
pe.p = peritoneal epithelium.
f = funnel of sperm duct.
m.s = muscular sac (=autospermatheca of Phreodriloides).
p = penis.
p.s = penial sac.
spt.d = spermathecal duct.
sp.g = spermiducal gland.
v.d = sperm duct.

Fig.

1. Diagrammatic lateral view of spermathecal and male genital apparatus. [The lining of the penial and muscular sacs is not to be interpreted from that represented in the figure (*vide* figs. 4 and 8).]
2. Ground plan of the same apparatus.
3. Wall of spermiducal gland.
4. Section through penial and muscular sac, so as to pass through the entrant point of the spermathecal duct.
5. Section through the ampulla and bulb of spermatheca, showing the spermathecal duct within the bulb.
6. Section through spermathecal duct.

7A 7B, 7C. Series of sections showing the relations of spermathecal duct, bulb, and ampulla *inter se*. Sections 7A and 7B are cut obliquely, and so show the ampulla. Section 7C is strictly transverse through the bulb. Sections 7A and 7B are consecutive.

8. Part of wall of penial sac.
9. Photograph of section showing the male pore, penial sac and muscular sac. Note the muscular sac behind and to the left of the penial sac, with which it is not continuous in this section.

CONTRIBUTIONS TO A KNOWLEDGE OF SOUTH AFRICAN OLIGOCHAETA.—Part II.

DESCRIPTION OF A NEW SPECIES OF PHREODRILUS

By Professor E. J. Goddard, B.A., D.Sc., and D. E. Malan, M.A.

(Received October 15, 1912.)

(Read October 16, 1912.)

Phreodrilus africanus, sp. nov.

Pl. XIV.

A large number of specimens of this form were obtained on the top of Table Mountain during August. A previous excursion during mid-summer had proved unsuccessful, and the same result has been experienced during summer-time in areas where other forms were obtained during August and September.

This constitutes the first record of a representative of the genus Phreodrilus in Africa, although a species has been described from Kerguelen Island. This genus is the only representative of the family which includes species from more than one land area, and it now includes forms from South America, Kerguelen Island, New Zealand, Campbell Islands, and South Africa. It is highly probable, however, that Phreodrilus is the central and most primitive genus, and thus enjoys a much wider distribution than the other genera, which in all probability have arisen in the areas they now occupy.

The genus, as is the case in each of the various genera of the family, differs from the others in regard to the spermathecae and their communications with the exterior. It will be seen later that the new species herein described is peculiar in common with a few other species in that the spermathecal pores are situated towards the dorsal side of the body, and that this represents an intermediate condition between what obtains in many species of Phreodrilus in which the pores have retained their more primitive ventral position, and those genera in which the spermathecal ducts have either been displaced towards the dorsal side to communicate with the male or female genital apparatus, or have disappeared along with the spermathecae. On these grounds the institution of a new genus would here be necessary were it not that a similar shifting of the pores dorsally is, as mentioned above, found in some other species occurring in other parts, as in New Zealand.

Externals.—

Length, 30 mm. extended.
Breadth, 1 mm. extended.

The setae in general are arranged in two dorso-lateral and two ventro-lateral groups.

In the ventro-lateral groups there is a pair of setae, one of which is sigmoid, simple, and longer; the other bifid, more strongly sigmoid, and shorter. In some segments the setae are either both simple, or one bears a very indistinct notch.

The dorsal setae are elongate and capilliform, and in some of the more anterior segments three were noted in each bundle.

The clitellum extends through segments xii and xiii, and is well developed both on the dorsal and ventral aspects, but extends further forwards dorsally than ventrally. Ventrally it covers only the posterior part of xii. The male genital pore opens in segment xii near its posterior margin.

The female pore is situated immediately behind the septum separating xii and xiii, but in the individuals examined was not very distinct. An indistinct structure representing an oviduct was followed for some distance upwards from each female pore.

The spermathecal pores are situated on the dorsal side of xiii.

Spermathecae.—These structures resemble in their disposition and extent those of *P. beddardi.* As noted previously, the pores are situated on the dorsal side of segment xiii towards its posterior margin. The septa are very indistinct, and in counting the segments the segmental dilatations of the alimentary canal have been used as a check.

From each pore the duct passes backwards, that on one side being horizontal and dorsal to the mass of sperms in xiii and xiv, and then passing obliquely backwards and downwards through the posterior portion of xiv behind the sperm mass, through xv to the posterior region of xvi. The duct of the other side passes directly obliquely backwards ventral to the sperm mass mentioned above. In the posterior portion of xvi both ducts turn on themselves, and become much wider and more heavily equipped with musculature. This widened structure then passes through the septum separating xvi and xvii into the thin-walled spermathecal chamber. Each spermathecal chamber consists of a horizontal ventral portion and a posterior vertical limb. The horizontal division extends through xvii and xviii into the anterior portion of xix. The ascending or vertical limb of the spermatheca of one side extends from the posterior limits of xix, where it is dorsal to the alimentary canal to the septum separating xviii and xix, where it passes into the ventral chamber in xix. The ascending portion of the spermatheca of the other side lies entirely in xviii, and that part of it which is dorsal to the alimentary canal passes downwards to join the ventral chamber immediately in front of the septum separating segments xviii and xix.

The wall of the anterior part of the spermathecal duct in the region of the pore is peculiar in that the anterior wall is peculiarly thickened and glandular. This thickening, which is composed of elongate columnar cells, is nothing more than a continuation of the clitellar epidermis. Strangely enough, although the clitellar tissue is still well developed behind the position of the pore, the posterior wall of the duct is thin and non-glandular, being composed of a flattened epithelium with spherical nuclei. In longitudinal sections the anterior part of the duct, cut somewhat obliquely, is plano-convex, the posterior side being straight, the anterior side concavo-convex, with the convexity directed downwards and forwards. Surrounding the epithelium of this part of the duct is an indistinct musculature. Behind this region the duct is very fine and composed of an epithelium of cuneate cells (about eight appear in a transverse section) compactly arranged and with ovoid nuclei. External to the epithelium is a thin highly refringent yet indistinct layer, as seen in transverse sections. This layer when seen in tangential sections of the wall has a striated appearance, and even in transverse sections of the duct there is an appearance of striation in the outer portions of the epithelial cells. The lumen of the duct is very minute, and particularly in the xvith segment, where the spermathecal duct turns on itself, the structure appears markedly striated and rigid. After turning on itself the lumen increases greatly in size, and the whole structure becomes greatly expanded. Further, the cells of the epithelium become very much larger and resemble in appearance the cells of the spermathecal gland, the protoplasm becoming vacuolated and the spherical nuclei losing their central position which they occupy in the narrower portion of the duct, and becoming situated towards the outer portion of the cells. This terminal portion situated in the posterior region of segment xvi appears as a globular dilatation. It passes backwards to join the ampullae of the spermathecae. The anterior portion of the ampullae merges histologically into the sac. The posterior portion has its wall composed of a flattened epithelium with spherical nuclei.

Male Organs.—A pair of testes is present in xi, attached to the posterior surface of the anterior septum.

Segments ix, x, xi, xii, xiii and xiv contain large masses of spermatozoa in various stages of development, enclosed in definite "sperm" sacs. Mature spermatozoa were found in the spermathecae.

The funnel of the sperm duct lies in segment xi, and, as is so frequently the case in Phreodrilidae, there is attached to its anterior face a mass of material taking in part a deep stain. By some they have been considered to be spermatozoa, but in the specimens of this new form examined by us they are so clearly continuous with the cells of the funnel that we regard them as consisting of long cilia. The central portion of the mass, unlike the anterior and posterior portions, has taken an intense blue stain with hæmatoxylin, and this is probably due to some secretion. Further, the whole mass is so compact and the area of the deeply stained portion is so regular. The funnel itself is composed of large cells appearing in sections as oblong shaped, with a slightly elongate nucleus centrally situated.

The spermiducal gland occupies the greater portion of segment xii. It is a large U-shaped structure, with its convexity directed ventrally. The anterior limb lies close behind the anterior septum of segment xii, its posterior limb immediately in front of the penial sac. Its wall is composed of large vacuolated cells with basally situated spherical nucleus.

The posterior limb rises to about the height of the centre of the segment and then becomes strongly attenuated, but the cells of this attenuated portion do not differ from those of the wide portion of the duct except in size.

The thin tubular end of the spermiducal gland is now joined by the sperm duct. The atrium thus formed is composed of flattened epithelial cells and almost immediately enters the penis.

The penial sac communicates with the exterior towards the posterior region of xii. It is a very long structure reaching to the middle of the height of the segment. In connection with its upper extremity is a band of retractor muscle; and a large mass of muscular material is attached to the middle of its anterior surface.

Its wall is composed of the three sets of elements usually present. Its inner epithelium is composed of loosely arranged cells with slightly elongate nuclei. The outer layer is constituted by an indistinct peritoneal epithelium with flattened cells. It bears a very close resemblance to the corresponding structure in Gondwanaedrilus.

The penis is peculiar in that it appears as a double tube. It is an elongate slender structure extending practically the whole length of the penial chamber.

Its outer surface is constituted by a folded epithelium of squarish cells with spherical nuclei, and bearing a strong resemblance to the inner layer of the penial chamber. Beneath this epithelium is a basement membrane, and within this there is a clear and indistinct layer in which in places spherical nuclei can be detected. The continuation of the atrium passes through the middle of the cavity of this structure to communicate with the exterior at the extremity of the penis.

At the base of penis there is a slightly better development of tissue between the central canal and the outer epithelium, on the inner side of the latter.

There can be little doubt that this penis is the correspondent of the solid penis as represented in other forms such as Gondwanaedrilus and Astacopsidrilus. Even in these forms the intermediate tissue is of a spongy indistinct nature.

The special interest in this penial structure lies in the suggestion that we can now form possibly an idea of the significance of the atrial sac in such forms as *P. beddardi* and *P. subterraneus.*

In both these forms the atrium is enclosed in an "atrial sac" which extends practically from the point of entrance of the sperm duct into the attenuated portion of the spermiducal gland, to the extremity of the penis. The wall of this atrial sac is continuous with that of the penial sac. Now a transverse section through the penis of such a form as *P. beddardi* would be essentially similar to a section through the hollow penis of the newly described form. Further, a transverse section through the atrial sac and its contained atrium would also be essentially similar to a section through the penis of the new form, since the wall of the atrial sac is continuous with that of the penial sac. The strands of muscles which stretch across the atrial sac would then represent the missing or degenerate intermediate tissue in the new form. If we imagine that the upper rim of the penial sac where it passes into the penis in *P. beddardi* were extended upwards to the point where the spermduct enters the spermiducal gland to form the atrium, and further that the wall of the penis in the same form (which would now be greatly elongated) became or remained confluent with the wall of the atrial sac, we would then have the same structure in the penial sac and its contents as obtain in the new form. This is made clearer in the diagrams represented in the figures.

In fact the penis of the new form is constricted as represented in the diagrams, and this constriction might well correspond to the region of confluence of the penial wall and that of the atrial sac in *P. beddardi.*

Female Organs.—The female pores, situated in the anterior region of segment xiii, have connected with them a short tube which passes upwards and forwards a short distance, and, piercing the septum, enters the xiith segment. The ovaries are attached to the anterior wall of segment xii. Masses of developing ova are found in segments xiii, xiv, and xv. The masses in xiv and xv are contained in a sac in close apposition with (if not continuous with) the large sperm sac of those segments. Similarly the other masses are contained in thin-walled sacs.

Remarks.

The two most interesting features of the new form concern the position of the spermathecal apertures and the peculiar penial structure. It is interesting to note that if what we have suggested in discussing the relation of the penis in *P. africanus* to the atrial sac of *P. beddardi* be correct, both forms have the spermathecal pores dorsally situated.

There can be little doubt that the ventral position of the independent pores in most species of Phreodrilus represents the more primitive condition. In all the other genera the spermathecae are either absent or functionless on the one hand, or communicate with the exterior indirectly by way of the male or female genital ducts.

In the latter case the ducts pass upwards towards the dorsal side before entering the male or female ducts.

It is in this relation that the dorsal disposition of the anterior terminal portions of the spermathecal ducts is interesting, since it is so clearly intermediate between what obtains in most species of Phreodrilus on the one hand and all other genera on the other.

In a recent paper dealing with the genus Gondwanaedrilus we pointed out the existence of a chamber which is an elongation backwards of the penial chamber and the correspondent of the "autospermatheca" of Phreodriloides. This chamber was apparently then evolved before the loss of the spermathecae in Phreodriloides, since the spermathecae are still present in Gondwanaedrilus. Before concluding this we considered the suggestion that the spermathecal structures in Gondwanaedrilus might be comparable with the peculiar structures of that name as found in Eudrilidae, and not with the more typically Oligochaetan structures as found in Phreodrilus.

This idea we did not support since the anterior part, at least, of the spermathecal chambers showed a well-developed cellular structure of a different nature to that found in coelomic sacs, although the epithelium was of a loose nature. We receive support in this conclusion from the dorsal disposition of the pores, etc., in *P. beddardi* and *P. africanus*.

The new form undoubtedly finds its nearest allies in *P. beddardi* and *P. subterraneus*—both New Zealand forms; and this distribution may yet prove of great significance.

EXPLANATION OF PLATE XIV.

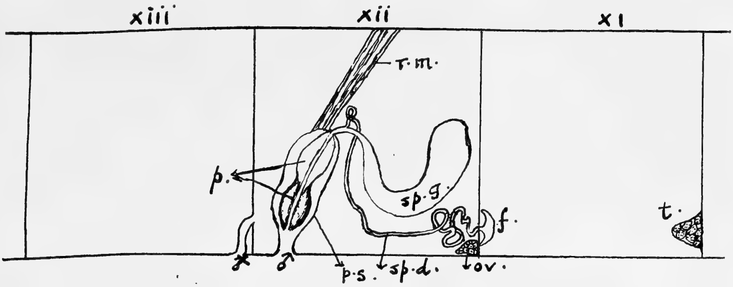
a = ampulla of spermatheca.
a' = ampulla of other side.
at = atrium.
at.s = atrial sac.
d = dilatation of spermathecal duct before entering ampulla.
f = funnel of sperm duct.
ov = ovary.
p = penis.
p.s = penial sac.
r.m = retractor muscle (much exaggerated in the diagram).
sp.d = sperm duct.
sp.g = spermiducal gland.
sp.s = sperm sac.
spt.p = spermathecal pore.
spt.d = spermathecal duct.
te = testis.

Figs

1. Section (diagrammatic) showing the position of the gonads, and the structure of the male genital apparatus.
2. Diagrammatic representation of the spermathecae.

3, 4, 5, and 6. Diagrams representing the relations of the penis to the atrial sac.

3. Solid penis as in Astacopsidrilus and Gondwanaedrilus.
4. Hollow penis as in *Phreodrilus africanus*.
5. Hypothetical intermediate stage in which only half of the penis as represented in figs. 3 and 4 is free in the penial sac; the other half represents the atrial sac of *Phreodrilus beddardi* and *P. subterraneus*.
6. Atrial sac and penis of *P. beddardi* and *P. subterraneus*.



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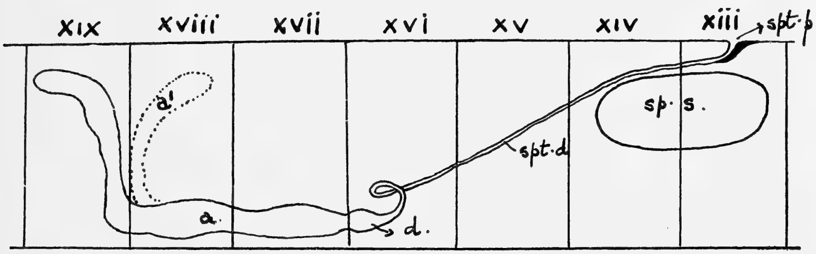

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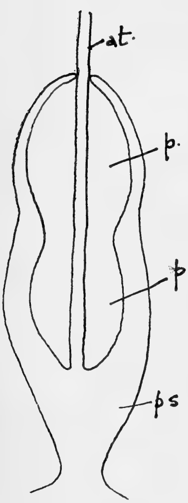

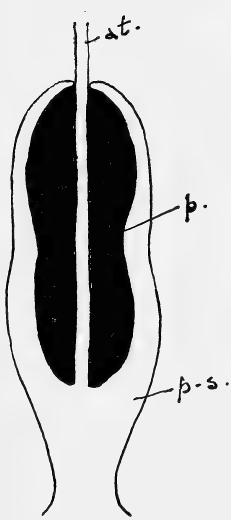

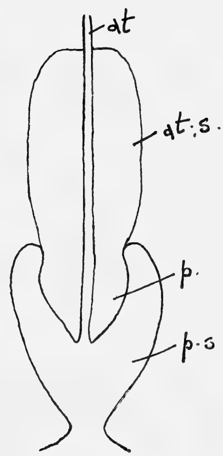

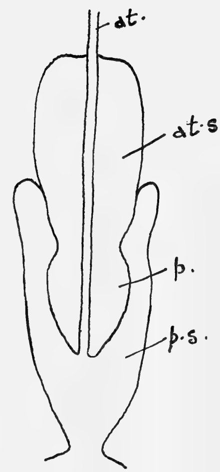

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SOUTH AFRICAN OLIGOCHÆTA.

CONTRIBUTIONS TO A KNOWLEDGE OF SOUTH AFRICAN HIRUDINEA.

ON SOME POINTS IN THE ANATOMY OF *MARSUPIOBDELLA AFRICANA*.

By Professor E. J. Goddard, B.A., D.Sc., and D. E. Malan, M.A.

(Received October 15, 1912.)

(Read October 16, 1912.)

Pls. XV.–XVII.

Marsupiobdella africana.

Recently we described * the externals of this form, and laid down the diagnostic characters of the new genus.

We propose in this brief paper to deal with the more interesting of the internal structures which have been specially modified by the development of the brood pouch, which is so enormously developed and unique as an internal structure in the Hirudinea.

The chief modifications concern the digestive, reproductive, nervous, and muscle systems, and these are the result of displacement.

Preliminarily, we take this opportunity of rectifying an omission. In the previous description we omitted to mention the presence of a pair of eyes on the second annulus.

Body Wall and Brood Pouch.—The brood pouch occupies the greater portion of the body extending in a median longitudinal section through somites xv–xix inclusive. Transverse sections show clearly that both anteriorly and posteriorly horns are given off, and the importance of these varies according to the contents of the pouch, and these continue the pouch forwards into xiv and backwards into xx. Within the pouch we have found young in various stages of development from the segmenting egg to the fully developed young. The extensions and relations of the pouch to other body structures are clearly shown in the figures.

The body wall has the typical Glossiphonid appearance, and the same applies in regard to the general body structure and sinuses. The great

* "Annals of South African Museum," vol. xi., 1912, p. 309.

development of the brood pouch brings about a remarkable tenuity of the body wall and a displacement of the organs to the dorsal and dorso-lateral regions.

The musculature of the body wall is typically developed in the regions anterior and posterior to the brood pouch, but the ventral wall of the brood pouch has a much smaller development of muscles than the dorsal. However, this ventral wall is clearly seen to be the original, or rather primitive, ventral wall, the muscle fibres being continuous with those of the anterior and posterior regions. The dorsal and lateral walls of the pouch, however, are devoid of any musculature comparable with the transverse and longitudinal muscles of the body wall. The internal lining layer of the pouch consists of an irregular and generally indistinct epithelium which grades into a faint musculature in parts.

The greater portion of the dorsal and lateral regions of the body in the vicinity of the pouch is occupied by the digestive and sinus systems.

In the anterior and posterior parts of the body structures which agree in their disposition with the limits of the somites as mapped out from external studies are developed which apparently correspond to septa, and these give great assistance in mapping in the distribution of the various organs with reference to the somites, which would otherwise be impossible owing to displacement caused by the great development of the pouch.

It is clear that the pouch has not been formed by an intensification of the condition found in other Glossiphoniidae where a temporary pouch is formed by an inflection of the edges of the body ventrally, but is a specially developed structure, as is clearly shown by the nature of the dorsal and ventral walls, each of which shows no musculature other than that characteristic of their respective superficies in other Glossiphoniidae.

The pouch occupies the position which is taken, at least ventrally, by the large sac-like ovaries of other Glossiphoniidae, and it is highly probable that the dilated portions of these sacs have lost their germinal function and become united to serve as a brood pouch. This idea is supported not only by the position of the pouch, but also by the paired nature of the pouch as indicated by the anterior and posterior horns. This has led to a restriction of the germinal area to the anterior portion of the ovary as it is found in other Glossiphoniidae, and also to a displacement of the same forwards by the growth of the pouch.

Alimentary Canal.—This structure is divisible into the same regions as that of other Glossiphoniidae.

The proboscis extends backwards as far as somite xi, nearer the dorsal than the ventral side of the animal. The oesophagus then passes upwards and backwards over the vesicula seminalis and in somite xiii descends behind that structure to pass into the ovary. In the posterior region of xiii it emerges from the ovary and then again ascends obliquely backwards in xiv. In xv it has reached the normal level and then passes into the crop, which extends along the middle line above the brood pouch. The crop gives off six pairs of caeca, which arise either in somites xiv–xix inclusive or in xv–xx inclusive.

The caeca of the crop, like the oesophagus, are very thin-walled, and there is some difficulty in tracing the structures of the middle portion of the canal. The caeca extend outwards along the sides of the brood pouch as far as the meeting-line of dorsal and ventral body surfaces.

The last pair of crop caeca arise at about the limit of posterior extension of the brood sac in the middle line.

The stomach gives off four pairs of diverticula, as it passes obliquely backwards and downwards behind the brood pouch.

The most marked features of the alimentary canal are the passage of the oesophagus through the ovary, and the exceedingly thin nature of the wall of the canal between the proboscis and the posterior portion of the crop.

As mentioned in the description of the female organs, the ovary is enclosed in a layer of flattened cells which become ellipsoidal at the points of entrance and exit of the oesophagus. The oesophageal wall consists of a single layer of flattened epithelial cells with elongate nuclei. This wall is in close apposition with the inner surface of the ovary and thus appears as an internal bounding layer. It is thus apparent that the ovary has invested the oesophagus.

Above the oesophagus is the dorsal sinus, which descends and ascends with the former in somites xiii and xiv. In xiii, however, it does not pierce the ovary, as can be understood, but rests on the dorsal surface of the latter, partly invested by the outer layer of cells of the ovary.

Reproductive Organs.—The male pore is situated between annul 21 and 22 of the ventral surface, that is between somites xi and xii.

The female pore occurs between annuli 23 and 24, that is, between the second and third annuli of somite xii.

There are six pairs of testes, situated in somites xiv–xix, a position which corresponds with that in other Glossiphoniidae.

They are greatly drawn out in a dorso-ventral direction and stretch along each side of the body in a vertical direction in a crescentic fashion. The third and fourth pairs stretch along the outer sides of the brood pouch.

Masses of mature spermatozoa occur in sinuses in the dorsal portion of the brood pouch region of the body, and ventrally anterior and posterior to the pouch.

The male ducts are interesting in that the vas deferens communicates anteriorly with a loop which communicates with the vesicula seminalis. The formation of this loop is undoubtedly brought about by the displacement due to the pouch. Otherwise the male ducts agree with those of other Glossiphoniidae.

The ovary is an unpaired hollow organ, and differs to a remarkable extent from the large sac-like ovaries of the other Glossiphoniidae, in which the ovaries occupy a large portion of the body. In many, for example, they stretch from somites xiii–xviii inclusive, and constitute a large portion of a transverse section in this region. In Marsupiobdella the ovary is limited to somite xiii, and would thus correspond to the anterior portions of the ovaries of other genera. It is enclosed in a layer of follicle cells which are ellipsoidal in places. The ovary is further peculiar in that the oesophagus pierces its dorsal wall, and passing through the cavity of the organ emerges through the posterior wall. The follicular cells of the ovary pass upwards for some distance around the oesophagus from its point of entrance into and exit from the ovary, and become ellipsoidal.

The external limiting layer is otherwise composed of flattened cells essentially similar to those limiting the brood pouch internally, and this may be taken to support the suggestion that the latter represents the posterior portion of the typical Glossiphonid ovary.

The tracing of the female ducts has been very difficult and unsatisfactory. The female pore, and two indistinct structures with convoluted walls which undoubtedly represents the oviducts were made out. The ducts pass from the ovary downwards towards the female aperture, but although there is every indication that they would communicate with the exterior, in a study of serial sections it is seen that the ducts turn near the pore upwards and backwards towards the antero-dorsal surface of the brood pouch. This portion directed upwards and backwards really represents part of the ovary of other Glossiphoniidae. No distinct opening into the brood pouch could be made out. There can be no doubt, however, that such communications do exist, and that the eggs pass directly into the brood pouch, and in all probability are fertilised in that sac.

The failure to find definite openings of the oviducts into the pouch is readily explained by the presence of well-advanced embryos or segmenting ova in the pouch, and by the small size and immature nature of the ova in the ovary. The specimens were all taken apparently after the breeding season, or, rather, towards the close of the same. Such a closure of the female ducts, in other Hirudinea has frequently been noted by one of us during the resting season.

The abundance of spermatozoa in the dorsal sinus and other parts of the body indicates that in all probability impregnation is hypodermic as in species of Glossiphonia, and this would be greatly facilitated by the delicate nature of the body wall in the brood pouch region.

Lastly, in specimens in which segmenting ova are present in the pouch, the ventral aperture of the pouch is closed, so that no other method of fertilisation seems possible. The sole function of the pore is to allow of the escape of the young.

Nervous System.—The course of this system will be readily understood from the diagrams. It passes backwards in the ventral median line as far as somite xv, and then ascends immediately in front of the anterior wall of the brood pouch to the dorsal side, between the two anterior horns of the brood pouch.

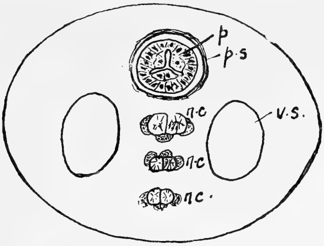
Transverse sections through the brood pouch region show the nerve cord in a median triangular projection of the dorsal body substance into the brood pouch.

The cord descends again behind the brood pouch, in close association with the posterior wall of the latter.

EXPLANATION OF FIGURES OF PLATES XV.–XVII.

b.p.a = aperture of brood pouch.
b.p.h.a = anterior horn of brood pouch.
br.p = brood pouch.
d.s = dorsal sinus.
caec = caecum of crop.
h = ejaculatory horn.
n. (*vide* figs. 4 and 10).
n.c = nerve cord.
oe = oesophagus.
oe.c = crop.
ov = ovary.
ov.d = oviduct passing downwards towards the obsolete female pore (this represents the true oviduct of other Glossiphoniidae).
p = proboscis.
p.s = proboscis sheath.
s. (*vide* figs. 2 and 10).
t = testis.
*t*3·4 = position of third or fourth pair of testes.
v.d = vas deferens.
v.s = vesicula seminalis.
x (*vide* figs. 2, 10, and 11).
y (*vide* figs. 3 and 10).
z (*vide* figs. 3 and 10).
ep = external epithelium of ovary, passing into muscular tissue (*ep.m*) comparable with lining layer of brood pouch.

FIGS.
1–9. Represent transverse sections through the more characteristic regions from the anterior end to the middle of the brood pouch.
10. Reconstruction of the male genital apparatus (compare with figs. 1, 2, 3, and 4).
11. Diagrammatic sagittal section to show the relations of the alimentary canal and female genital organs.
12. Reconstruction of brood pouch (in ground plan).
13. Transverse section through ovary, to show the relations of ovary, oesophagus, and dorsal sinus *inter se*.
14. Photograph of section showing segmenting eggs in brood pouch.
15. Photograph of transverse section through brood pouch containing fully developed young. Note the deeply stained crop caeca in the young and the testes and large sinuses in the lateral body wall of the adult.
16. Photograph of transverse section through the brood pouch, passing through the pore. Note the extrusion of a young individual through the pore and the testes (3rd or 4th pair) in the lateral body wall of the adult.



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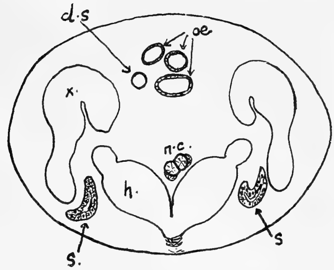

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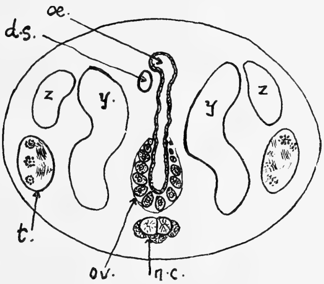

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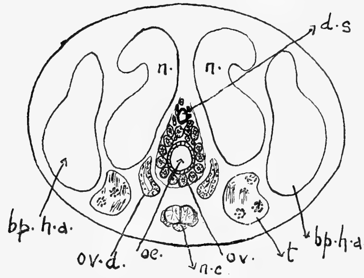

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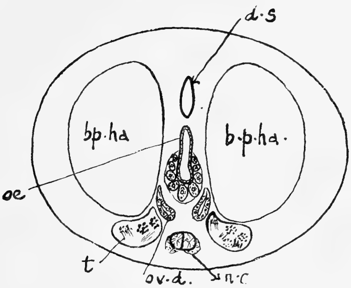

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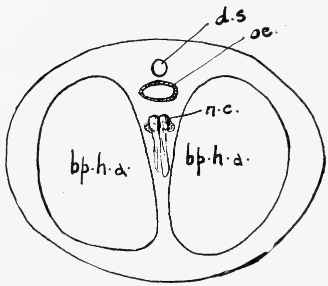

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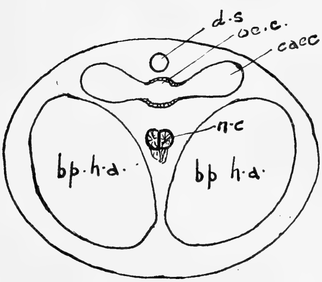

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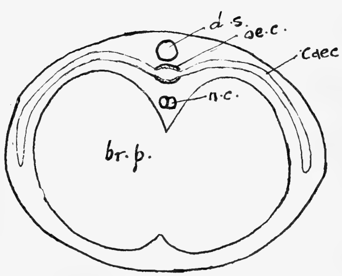

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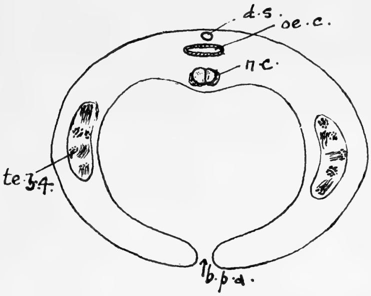
SOUTH AFRICAN HIRUDINEA.



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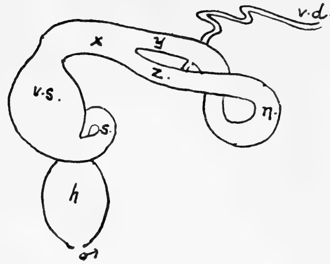

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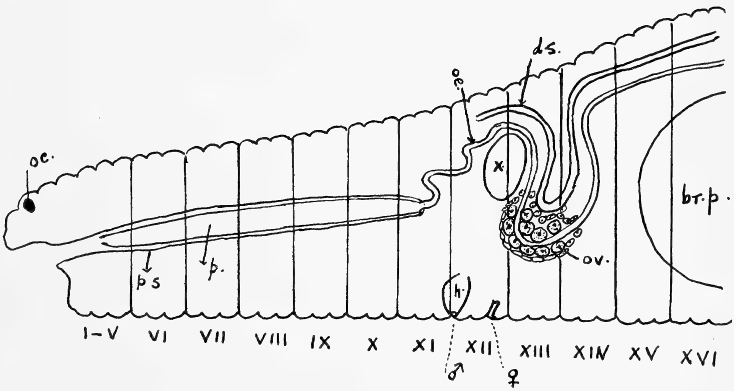

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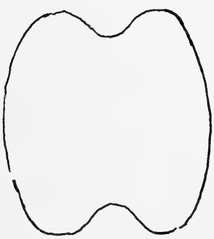

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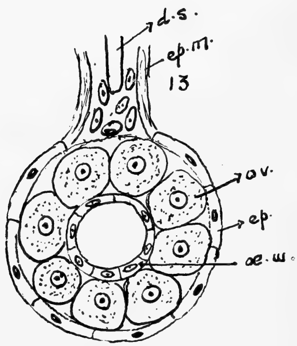

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SOUTH AFRICAN HIRUDINEA.

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SOUTH AFRICAN HIRUDINEA.

A NEW SPECIES OF HAEMATOXYLON (LEGUMINOSAE-CAESALPINEAE) FROM GREAT NAMAQUALAND.*

By Edith L. Stephens, B.A., F.L.S.

(Plate XVIII.)

(Received November 5, 1912.)

(Read April 16, 1913.)

The discovery of a South African species of Haematoxylon is of particular interest, as the genus has hitherto been represented only by one species—*H. campecheanum*, L., the log-wood tree, a native of Mexico, Central America, the northern parts of South America, and the West Indies. The species here described was found among rocks at Holoog, in Great Namaqualand, by Dr. H. H. W. Pearson, in February 1909, during the Percy Sladen Memorial Expedition in South-West Africa, 1908–9. It is interesting to note that a species of the closely allied and likewise typically tropical American genus Hoffmanseggia was found at the same place (*H. Burchelli*, DC.; Pearson 4122). This genus ranges from Patagonia to Mexico, with two South African species, neither of which has hitherto been recorded from the South-West African Region.

Haematoxylon africanum, E. L. Stephens (sp. nov.); a *H. campecheanum* differt habitu fruticoso, partibus novellis et inflorescentia pauciter pilosis glandulisque, foliis minoribus, inflorescentia terminali longiore paucioribus floribusque, calyce bilabiato, petalis staminibusque longioribus.

Frutex, 1–1·5 M. alta (Pearson), partibus novellis plus minusve pilosis, pilis crispulis vel interdum plumoso-ramentaceis; ramis glabris rufescentibus, ramulis perbrevissimis stipulis persistentibus foliorum delapsorum incrassatis, apicibus 8–3 foliis coronatis. Folia patentia demum reflexa, paripinnata, ad 1 cm. longa, petiolata, petiolo ad 2 mm. longo, foliolis 3-jugis breviter petiolulatis obcordatis vel late obcordatis, pulverulentis, glauco-viridibus, circa 6 mm. longa lataque, stipulis ovato-subulatis parvulis rufescentibusque cum stipellis minutis fimbriatis petiolo communi plus minusve piloso, pilis crispulis, glandulis

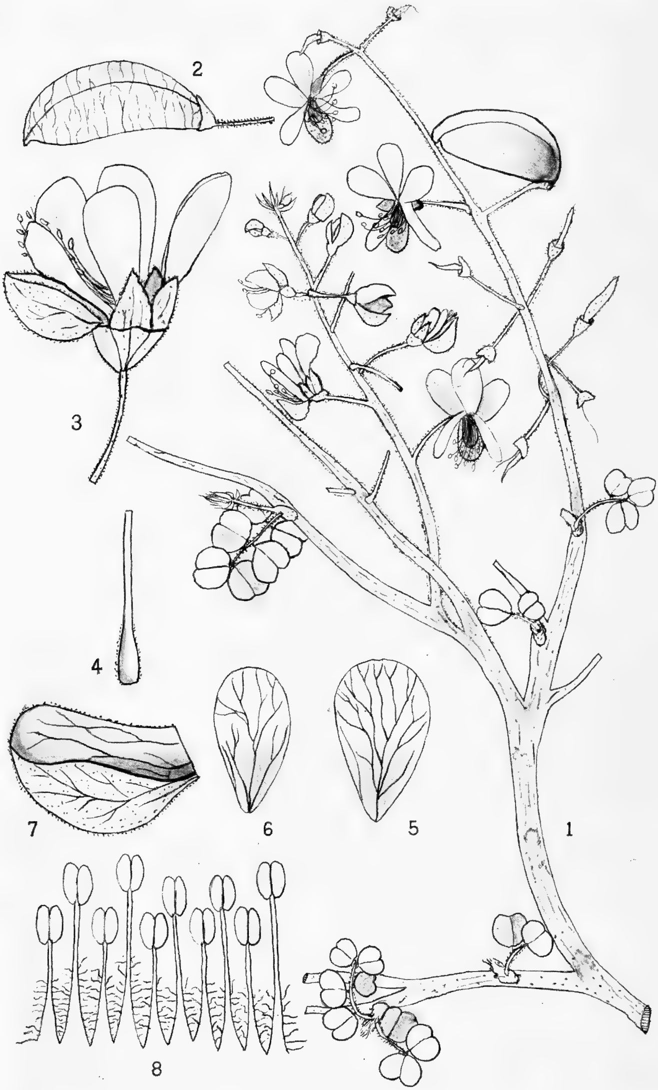
* Contributed from the Bolus Herbarium, South African College. Report of the Percy Sladen Memorial Expeditions in South-West Africa, No. 26. This investigation was assisted by a grant from the Union Government.

stipitatis brevibus interjectis, 4–8 mm. longo. Flores laxe racemosi, racemis terminalibus strictis ad 28 floris, 7–15 cm. longis; pedicellis 1–4 natis patentibus vel decurvis gracilibus 7–10 mm. longis, bracteis deciduis subulatis minutis vel rarius ad 3 mm. longis. Calyx tubo obliquo 10 nervio 2 mm. longo, bilabiatus, labio superiore 4 partito, segmentes oblique oblongo-lanceolatis, acutis, ciliatis, 3–4 mm. longis, inferiore majore integro naviculari 5–7 mm. longo. Petala obovata vel spathulata, flava, ad 1 cm. longa. Stamina 10 libera, filamentibus basim pilosis, 5–8 mm. longa, alternis longioribus. Ovarium superiore 2–3 ovulatum, glandulis stipitatis brevibus indusiatum; stylus filiformis; stigma simplex. Legumen oblique oblongum vel lineari-oblongum, 1–2 spermum, 3 cm. longum et 1 cm. latum. Spermum (? immaturum) 5 mm. longum et 3 mm. latum.

A shrub, 1–1·5 metres tall; the young twigs, petioles, and inflorescence more or less pilose with curled or plumose hairs, the branches glabrous and reddish-brown. The leaves are found singly or two or three together at the apices of short shoots, which are covered by the persistent stipules of former leaves. They are paripinnate and up to 1 cm. in length, with petiole about 2 mm. long, and with small reddish ovate-subulate stipules and minute fimbriate stipels. The leaflets are 3-jugate, shortly petiolulate, obcordate, pulverulent, grey-green in colour, and about 6 mm. long and broad; the common petiole is more or less pilose with curled hairs, among which occur short stalked glands. The flowers are arranged, up to 28 in number, in a lax straight raceme 7–15 cm. long, on slender spreading or recurved pedicels 7–10 mm. long; the whole inflorescence is more or less pilose and glandular. The deciduous bracts are minute and subulate, or rarely reach a length of 3 mm. The calyx is bilabiate, the upper lip being 4-partite, with oblong-lanceolate acute ciliate segments 3–4 mm. long, and the lower lip consisting of a single boat-shaped sepal 5–7 mm. long; the calyx-tube is oblique, 10-nerved, and 2 mm. long. The petals are obovate or spathulate, yellow, and 1 cm. long. The filaments of the stamens are pilose at the base and 5–8 mm. long, the alternate longer. The ovary is superior, 2–3 ovuled, and covered with short stalked glands; the style is filiform, and the stigma simple. The pod is obliquely oblong or linear-oblong, one or two seeded, 3 cm. long and 1 cm. broad. The largest seed seen (probably immature) was 5 mm. long and 3 mm. broad.

This species differs from *H. campecheanum* by its shrubby habit, by its more or less pilose and glandular young parts and inflorescence, by its smaller leaves, by its longer fewer-flowered and terminal inflorescence, by its bilabiate calyx, and by its longer petals and stamens.

Great Namaqualand. Among rocks near Holoog, Pearson, 4134.



A. M. K. del. West, Newman proc.

HÆMATOXYLON AFRICANUM, *E. L. Stephens*, n. sp.

DESCRIPTION OF PLATE XVIII.

HAEMATOXYLON AFRICANUM, E. L. Stephens, n. sp.

FIG. 1. End of a flowering branch. Natural size.
,, 2. Legume. Natural size.
,, 3. Flower, side view. × 2½.
,, 4. Pistil. × 3.
,, 5 & 6. Petals. × 3.
,, 7. Large sepal. × 3.
,, 8. Stamens. × 3.

NOTES ON THE POLLINATION OF SOME SOUTH AFRICAN CYCADS.

By G. Rattray, D.Sc. Communicated by H. H. W. Pearson.

(Received November 5, 1912.)

(Read April 16, 1913.)

The following notes on the pollination of the Cycads which grow within easy reach of East London are the result of observations made during the last seven or eight years, sometimes sporadically, sometimes systematically.

I have been able for a time to keep over a dozen cones of Stangeria under continuous observation during the critical period and verify my former conclusions.

The notes contain little that is new; by far the most important link in the chain of evidence for the insect pollination of *Encephalartos villosus* was discovered by Miss Pegler and recorded by Professor Pearson in 1906 (*Transactions* of the South African Philosophical Society, vol. xvi., part 4), while my general conclusions are largely those foreshadowed by the latter at the same date.

Encephalartos Altensteinii, Lehm.

It is hard to say what is the natural habitat of this species. Along the deep valleys eroded by our rivers and streams it is found now clinging precariously to the face or crowning the top of some precipitous krantz now hidden amid the shrubs and trees of a wooded ravine. Seldom or never does it leave the river valley for the open grass formation of the surrounding country. From its relatively greater frequence—at times it is almost social—in exposed situations and the almost complete absence of cone production in the woodland forms, I am disposed to regard it as a sun rather than a shade plant. In the open form cones are produced in fair abundance, there being few years in which some cannot be obtained, but a considerable variation exists in regard to the time at which they make their appearance. I have found them just emerging as early as the middle of November and as late as the first week of February of the following year. In the great majority, however, the cones are visible in the last week of December. Coning is heralded by a flattening out of the apex of the trunk and the gradual depression of the leaves from a semi-erect to a horizontal position, so that the full-grown cones come to occupy a comparatively conspicuous position—a point which may be regarded as equally favouring anemophily by exposing the cones to the full benefit of the wind, or entomophily, in the same manner as the entomophilous angiosperm does not conceal its attractive blossom among its leaves.

Staminate cones are somewhat more abundant than ovulate ones; not so much, however, because the number of male plants is greater than that of the female as because more of the former are produced on an individual stem. Female cones are usually borne in ones, twos, or threes, rarely more, while the males are produced in threes, fours, or fives, or even sevens, rarely ones or twos. There is also some evidence that male plants cone more frequently than females, although the number of specimens under observation would require to be sufficiently great to eliminate individual eccentricities before one could be certain.

The male cones mature and the microsporangia begin to dehisce about the second week of April on an average, but pollen continues to be shed for two weeks or longer. At this date the male cone is about 20 inches high, inclusive of the short peduncle. The sporophylls are widely separated, so that there is free play for the wind or the entrance of insect visitors. When ripe the cone is of a pale brown colour, and is a conspicuous object in contrast with the dull green of the leaves—a contrast which is intensified as the freshly shed pollen dusts all parts with a coating of white. A faint but distinct odour is emitted which is not unpleasant, yet with one exception I have observed few insect visitors until decomposition has begun. The single exception is formed by a species of curculionid beetles, which have been referred to the genus Phlæophagus. The most abundant species has a much-depressed body of dark shining brown colour, and the female is furnished with a long rostrum. In April, 1908, a single male cone, one of three which I collected and brought home wrapped in paper, yielded 437 individuals, and several escaped during the removal of the cone. Since that date I have again and again found these weevils in great abundance on the cones at the time the pollen is ripe. Their bodies are inevitably buried in pollen, and masses adhere to the base of the rostrum and to the legs.

In the specimens which I brought home in 1908 I found that the pollen was still adhering to their bodies three days after they were removed from the cone, although during that time they had had the free run of the room. Although I had known these weevils for some years previously, and knew that they possessed functional wings, I had never actually seen them flying, although at times there must have been dozens of them crawling all over the room in which I worked. As the point seemed of some importance, I tried dropping them suddenly from a height off the blade of a knife. After many hours of this diverting occupation I at last succeeded in making two or three spread their wings and entrust themselves to the air. (Need I add that the very next evening many of them flew round and round the room *sua sponte*.)

Two points were then established—that Phlæophagus could make a flight of some yards, and that pollen could adhere to its body for at least 60 hours.

At the time of pollination the female cone is 14 inches high with no visible peduncle. The colouring is an indefinite green with a suspicion of yellow, and could not be described as conspicuous. Nor is there any perceptible odour. Although I have examined over a score of female cones during the time the pollen is being shed and have had three under daily observation in my own garden I have never noted any separation of the sporophylls. Although I still feel bound to believe that it must occur, yet it must be only to a very limited extent—a condition which, while not altogether excluding anemophily in this species, certainly renders it much less probable; for the exposed parts of the sporophylls stand almost horizontally and do not overlap, so that unless the separation were very marked only wind-borne pollen coming horizontally could effect an entrance, and only those ovules on the side of the prevailing winds would be fertilised. But in all the cones which I have worked through, even from plants growing on the outside of a group, embryos had been formed in uniform proportions on all sides.

Long before I was aware that Phlæophagus visited the staminate cones of *E. Altensteinii* I knew that it was hardly possible to find a mature ovulate cone in which a large percentage of the ovules were not parasitised by the same insect, but was wholly unaware when the eggs were deposited. Miss Pegler's observations on *E. villosus*, recorded by Professor Pearson, suggested a line of inquiry when once I had proof that the male cones of *E. Altensteinii* were also visited by these weevils.

A visit paid on the third day to the two remaining male cones—found in April—showed that although there was still some fresh pollen the weevils had disappeared. Some thirty paces lower down the valley there was a female plant with two cones. An external examination of these revealed no sign of any insect, and as the sporophylls showed no sign of separation I concluded that wherever the insects had gone it was not to these. I was therefore much surprised, on cutting open one of the cones, to find scores of weevils present. Once past the barrier formed by the peltate portion of the sporophylls it was easy to see that their movements were comparatively unrestricted, especially near the cone axis. A lens examination showed traces of what might be pollen, and its presence was confirmed later by the microscope, when eleven out of twenty examined had pollen still adhering to their bodies. Unfortunately the figures are not of much value, as for several hours all the weevils were packed together in the same test tube and it is possible that a transference of pollen may have taken place.

I have since then found two other ovulate cones with pollen-bearing weevils.

In trying to work out the life-history of this interesting insect, I have found that the development from egg to adult coincides exactly with the period that elapses between the pollination and the disintegration of the female cone of *E. Altensteinii.* In ovules up to three months old one can find no trace of the insect at any stage of its development, while from June onwards they are easy to find. The life-history appears to be as follows: The eggs up to a dozen are deposited by the female, possibly with the help of the long rostrum in the tissues of the ovule in the micropylar region. The grubs live at the expense of the endosperm. The adult emerges within a few days of the disintegration of the cone through an opening in the side of the testa. The adult can live for three months without food and only a limited supply of air, but where or how this period is spent is uncertain. When the male cones are ripe the insects appear in large numbers, feed on the pollen for some days, and pair. The females then visit the ovulate cones and once more deposit the eggs.

The whole life-history appears so dependent on Encephalartos that it would be only reasonable to find that the Cycad had demanded a *quid pro quo* and had turned the visits to use.

While it is fairly easy to understand how both colour and odour attract these insects to the male cones it is more difficult to give an explanation of how they find their way to the female, but not more difficult than in the case of numerous other insects which seek out with unerring accuracy the plants which will afford the proper food for their larvæ.

Summary and Conclusion.

E. Altensteinii grows in wooded areas, but chiefly on the more exposed cliffs.

Its height enables it often to lift its cones above the surrounding vegetation and expose them to the action of the wind.

At the time of coning the leaves are depressed, fully exposing the cones.

No visible separation of the macrosporophylls has been observed, but as certain insects effect an entrance, wind-borne pollen might also do so. Ovules are fertilised almost equally on all sides.

The male cone is fairly conspicuous and emits a perceptible odour.

Insects, viz., weevils of the genus Phlæophagus, visit the male cones and thereafter, while pollen is still adhering to their bodies, the females visit the ovulate cones most probably to ovipost.

It would appear, therefore, that while nothing in the structure or position of the cones renders anemophily impossible or even improbable, entomophily is of common occurrence.

Encephalartos villosus, Lehm.

This species, which appears to reach its western limit somewhere near the Keiskama River, is confined to the macrophyllous woods and forests of the littoral belt. Of the eight South African species of Encephalartos which I have seen growing in their natural habitats, it is the only one which is distinctly a shade-loving plant. When brought from the forest and subjected to the greater insolation of the open garden or park the long, graceful leaves become stunted and assume a sickly yellowish-green appearance.

Around East London it is very abundant in the wooded ravines and forest belts which fringe the lower reaches of our larger rivers. Although the character and composition of these woods are by no means uniform, they are for the most part extremely dense save where man has entered with his pruning axe. Recently the main road which passes through part of the Fort Grey forest has been widened by clearing away the vegetation on both sides, and it is almost impossible to conceive a more impenetrable barrier than that presented by the margin of the standing forest, yet in the stillness and gloom of this area *E. villosus* may be found in abundance in all stages of growth and development—indicating that neither wind nor direct sunlight are indispensable to its propagation.

Subdividing the accessory vegetation of a forest flora into "underwood" and "herbaceous undergrowth," our species may be regarded as belonging to the latter in so far as it produces no aerial stem, and the organs of reproduction seldom attain a height of more than 2 feet above the level of the soil.

Almost without exception the other plants associated with it whose flowers attain approximately the same height, are markedly entomophilous. Of these by far the most abundant in the locality mentioned are species of Acanthaceæ and Labiatæ, belonging to the genera Isoglossa and Justicia in the one case and Salvia and Plectranthus in the other.

The frequency with which cones are produced under natural conditions has not yet been determined. None were observed during the period 1904–1906. In 1907 they were produced in considerable abundance in the Gonubie, Nahoon, and Buffalo valleys. Plants which I marked as coning in that year have up to the present (1912) not again developed cones, and indeed during these years I have only found an odd cone. In cultivation both male and female specimens produce cones almost every year. The cones emerge about the same time as those of *E. Altensteinii*, namely, the end of December, but the male cones appear to take a little longer to mature, the average date being about the first week of May.

The ripe male cone reaches a height of about 24–30 inches, and is of a conspicuous yellow colour. The sporophylls which in the immature cone imbricate descendingly separate widely. It is remarkable that in *E. villosus* the microsporophyll has become more highly differentiated than in any other Encephelartos with which I am acquainted, and the number of sporangia is considerably below the average of the genus. Chamberlain, quoting Miss F. G. Smith, gives the number as 500, but I have never found as many as 300, and would put the average down at about 275.

Pollen is, however, produced in abundance. The upper surface of each sporophyll is slightly concave and serves to collect the pollen from the sporophylls immediately above it.

It is suggestive of the inefficiency of the wind to disseminate the pollen of this species, and that one may visit a male cone day after day during the time the sporangia are dehiscing and find it laden with pollen, whereas in a wind-swept cone, such as even that of Stangeria, it is only after a period of great calmness that one sees an appreciable quantity of pollen on the cone.

As Professor Pearson pointed out some years ago, the mature male cone of *E. villosus* emits a most powerful and penetrating odour, which has been said to suggest a badly kept stable. It is no exaggeration to say that by an insect with no keener olfactory sense than our own the quarry may be scented from afar, nor is it an uncommon thing for the amateur gardener to bury with indecent haste what was an object of admiration a few weeks earlier. The first male cone I carefully observed grew in the garden of a friend. We watched and recorded its progress from week to week, but there came a day when I received a polite but firm request "to remove the disgusting thing if you have any further interest in it, as not only my family but my neighbours are beginning to complain." The odour is much stronger about sunset and in dull, cloudy weather than in sunlight.

Miss Pegler first noted that this odour served to attract a species of curculionid beetle of the genus Phlæophagus. Her observations were recorded by Pearson (*loc. cit.*), and form the most important link in regard to the evidence for the pollination of this species. I found the same beetle in vast numbers on two male cones of *E. villosus* in 1907, and in one of them which I brought home and kept under close observation I noted that two days later the weevils were pairing. As the life-history of these insects seems so interwoven with that of Encephalartos it may be worth recording that pairing occurs on the ♂ cones in the case of another weevil which frequents *E. Friderici Guilielmi*.

The female cone at the time of pollination has an average height of about 17 inches. [It has to be remembered that *E. villosus* forms no aerial stem, and that these figures therefore represent the height above the level of the ground.] The original green of the sporophylls has begun to fade into yellow, but has not yet attained the beautiful orange colour of the mature cone. As in the male, the sporophylls imbricate descendingly, and there is little or no separation at the time the microsporangia are dehiscing. It is therefore apparent that pollen settling down out of the air cannot find admission between the macrosporophylls. It is almost equally impossible to conceive how pollen borne horizontally could effect an entrance, and if it did one would expect to find only the ovules on the side of the prevailing wind fertilised. But although the results obtained by Professor Pearson and myself, after orienting the cones and examining every seed, showed that the fertilisation had occurred approximately equally on all sides, and in at least one of the cones examined I am quite certain that on two sides there were no male cones within a distance of several miles. From the nature of the imbrication only pollen carried by wind moving at an angle of at least 45° to the horizontal could possibly effect an entrance, and even then there is the difficulty of conceiving how it could reach the centrally directed micropyles. It has also to be remembered that the male cones are the taller, and that even if the wind was blowing at the required angle much the greater part of the pollen would be carried over the top of the average female cone.

An examination of almost any female cone from June onward reveals the fact that a proportion of the seeds, which may vary from 30 to 100 per cent. are parasitised by the same species of Phlæophagus as frequents the male cone. With the exception of two dead weevils which I found in June, 1907, with the rostrum embedded in the tissue of the ovules, and to one of which pollen masses were still adhering, I have never found the pollen-laden insects on female cones in the wild state, but in a specimen growing under almost natural conditions in our local park they were noticed in large numbers, and from the frequency with which the ovules are parasitised there can be no reasonable doubt but that the phenomenon is of regular occurrence.

Since the lower swollen peltate part of each sporophyll overlaps part of the two immediately below it, and as these curve inwardly where they meet, there is left at the time of pollination an opening large enough for a flattened insect of the Phlæophagus type to effect an easy entrance. The whole structure of the female cone of *E. villosus* and of one or two related species—also non-arborescent forms—differs in so many respects from the prevailing type seen in *E. Caffer*, *E. Lehmanni*, *E. latifrons*, and *E. Altensteinii*, &c., that one is almost forced to conclude that it has either retained or evolved a disposition of its parts suited to another method of pollination.

Summary and Conclusion.

E. villosus grows exclusively in the shade of macrophyllous woods and forests.

In many places where it flourishes the force of the wind must be reduced to a minimum.

Associated plants of the same height are almost without exception entomophilous.

The male cone is of a conspicuous colour and emits a powerful odour.

Curculionid beetles are attracted to the male cones.

The same species of insect visit the female cones to deposit their eggs in the ovules immediately after leaving the male cones and while pollen is still adhering to their bodies.

The descending imbrication of the female cone makes the admission of wind-borne pollen almost impossible.

E. villosus is entomophilous.

STANGERIA.

The species of Stangeria to which the following observations refer is that commonly known as *Stangeria Katzeri*, described and figured by Regel in *Gartenflora,* 1874.

In the neighbourhood of East London and from there to its western limit—the Kowie River—it is essentially a *grassland* or *savannah* plant, most abundant on grassy slopes with an east to south aspect. Although it seems to hug the forest fringe it rarely enters the woods or bush-covered valleys, and when it does seldom penetrates for more than a few yards.

It is by no means a rare plant, but its distribution is curiously interrupted; for the most part it is found in groups or colonies, which are separated from one another by well-marked but variable intervals.

In any one year the Stangerias of a particular colony may produce cones in abundance, while in neighbouring colonies cones are either extremely rare or altogether absent.

The cones make their appearance much later than those of the local species of Encephalartos, being rarely visible before the latter half of April. Male cones are produced much more abundantly than females, although the proportion varies from 14 : 1 to 5 : 3.

The mature male cone reaches a height of about 12 inches, including a peduncle of 4 inches, but the actual length depends to some extent on the surroundings. Where, from the grazing of herbivorous animals or from other causes, the grass is short, the total height may not exceed

7 inches, while, on the other hand, if the grass is long or the plant, as is frequently the case, is growing in a "Kommetje," the cones may reach a height of 15 inches. These figures indicate that an attempt is made to lift the cone above its surroundings, and thus expose it to some extent to the action of the wind.

The colour of the ripe male cone varies considerably. The sporophylls are covered externally by a coat of short matted tomentum of a brown or greyish-white colour. If, however, the cone has been exposed during its growth to the action of wind and rain, the tomentum gradually disappears, revealing the chlorophyll green of the underlying tissues. A slight but distinct odour is emitted while the pollen is being shed. It is difficult and possibly valueless to attempt to estimate the intensity of an odour, but I may say that it is not sufficiently powerful to affect my own olfactory nerves at a distance of more than about 2 feet. No insects have been observed to visit the cones, except the *Lepidopter zerenopsis*, sp., which deposits its eggs freely on all parts of the plant and the neighbouring grasses. The caterpillars of this insect are very destructive of all our local Cycads, but the eggs are deposited almost throughout the year and without any reference to the production of cones.

By the end of July (24th) * the sporophylls of the more vigorous male cones begin to show signs of separating; the process advances from the base upwards with extreme slowness. At the end of August (31st) those of the apical third are still tightly closed, and it is a fortnight later (September 14th) before they show signs of separating at the summit.

Before this however (17th), the peripheral microsporangia of the lower sporophylls have turned brown and discharged their pollen.

In all it takes from five to eight weeks for a single cone to discharge its pollen, and, allowing for variations in the time of ripening of cones, pollination may be effected any time during a period of ten weeks. It is not without significance that in this neighbourhood August and September are the windiest months of the year. Moreover, in June, July, August, and the first half of September there is little rainfall, and the vegetation of the grassland is at its lowest. The grasses are dry and shrivelled, and in many parts cropped short by cattle. At no other time of the year would a plant of the dimensions of Stangeria have so favourable an opportunity of disseminating its pollen by the agency of wind.

On the 21st of September I kept four male cones under observation for about half an hour each. A strong westerly wind had sprung up, and its violence was great enough to cause the cones to sway from side to side and sweep out the pollen in clouds, which could be followed for a short distance moving in an upward direction. I exposed a number of micro-

* The dates refer to the most vigorous specimen of one of 13 cones kept under continuous observation from the 13th of July to October, 1912.

scopic slides smeared with glycerine for about an hour at distances varying from 3 feet to ten paces from male cones, and in every case was successful in finding pollen grains, most being caught by a slide exposed on the top of an ant-heap about $3\frac{1}{4}$ feet high.

The distances from male cones are not great, but in the area where these observations were made male cones were growing 8 inches, 26 inches, 37 inches, and 54 inches from females, and it is thus clear that wind is able to convey the pollen of Stangeria sufficiently far to insure the pollination of a fair number of cones. The fact that most pollen was found on the slide exposed on an ant-heap would indicate that the pollen is carried well up into the air, and is therefore capable of being disseminated over a wide area.

At the time of the pollination the ovulate cones are from 5 to 7 inches high, and have a circumference of $7\frac{1}{4}$ inches. In all ordinary circumstances, and except where the surrounding grass has grown very rank, these dimensions are sufficiently great to insure an open way from above if not from the sides. The macrosporophylls are much larger and fewer in number than the microsporophylls, and are arranged in a series of six (rarely five or seven) vertical rows with ascending imbrication. In contrast to what has been observed in the case of Encephalartos, the macrosporophylls separate and open out at the time of pollination, the openings pointing upwards. The lower sporophylls in some cones open out considerably more than the upper. The whole arrangement seems adapted to catch pollen settling down out of the air rather than borne horizontally by wind currents. A careful study of the female cone at this stage will show that the pollen which falls on the smooth adaxial surface of any one sporophyll has much less chance of reaching the ovules of that sporophyll than it has of coming in contact with those which form the right and left of the two sporophylls immediately below it.

The sporophylls remain open for five or six weeks. No insects have been observed to visit the female cone, and none have been found in the seeds at any stage of their development. In some years a fair number of cones set seeds, and these are evenly distributed throughout the cone. I have records of only two cones in which the fertile seeds were confined to one side of the cone. One was found growing slantwise out of a hollow and in such a position that pollen, whether settling down from above or driven sidewise, could only reach one side. Unfortunately I did not see the cone until it was almost disintegrating, and cannot be perfectly certain that it occupied the same position at the time of pollination, although I have no reason for believing that it did not. The other was growing inside the bush on the slope of the east bank of the Nahoon, and was the specimen which had penetrated furthest into the woodland formation. Wind-borne pollen could only have reached it from the side on which the fertile seeds were found.

The comparatively long period—about nine months—which elapses between pollination and the maturing of the seeds, exposes the cones to many risks, so that it is difficult from mere field observations to estimate the frequency of pollination; but after allowing for the heavy toll levied by grass-fires, caterpillars, and the trampling of oxen, one is left with the impression that the production of seeds is not a very successful business. This impression is confirmed by the apparent rarity of seedlings, but again it has to be remembered that in a grass country it would need very careful and minute observation to pick out small plants, and consequently they may be commoner than one thinks.

This year I have labelled most of the female cones in a Stangeria colony, and hope to get more accurate data on this point.

In any case *Stangeria Katzeri* has very successfully adopted vegetative means of reproduction. Branches and suckers up to a dozen in number are found in almost every well-developed specimen.

Summary and Conclusion.

St. Katzeri grows in open grassland or savannah.

The male cones shed their pollen from the middle of August onward, when the grass is dry and shrivelled and high winds are common.

The male cones are sufficiently high to enable the wind to sweep out the pollen.

The sporophylls of the cones imbricate ascendingly; those of the female cone separate at the time of pollination. This arrangement is well adapted to catch pollen settling down from above.

Pollen has been caught on slides placed at distances which were greater than those separating several male and female cones.

No insect visitors which could effect pollination have been observed.

Pollination takes place in a fair number of cases, but does not appear to be of general occurrence.

Vegetative reproduction is common, and may have been adopted to supplement the more uncertain sexual method.

Anemophily holds good for *Stangeria Katzeri*.

The three species of Cycads considered in the present paper may be found in certain localities within a radius of a hundred yards—Stangeria in the grassland abutting sharply on the bush-covered valleys, *E. Altensteinii* on the steeper banks of the valley, and *E. villosus* in the shady depths of the valley itself; yet if my conclusions are correct they represent three stages or conditions in respect of their pollination.

Stangeria adheres to what we may assume to be the older and more primitive anemophilous method, and it is not without significance that there is much in its general habit and structure to suggest that it is nearer the ancestral stock morphologically than Encephalartos, *e.g.*, in its low fern-like habit, its leaf structure, its less differentiated sporophylls, its tendency towards a concentric structure of the cotyledonary bundles.

E. villosus, on the other hand, appears to have abandoned anemophily completely and to rely entirely on insect agency. There is no denying that the method is an expensive one, although not more so than in many other species of plants; but certainly, if one may judge from the number of young plants seen, it has proved successful. There are indications that owing to the greater certainty of entomophily *E. villosus* has been able to economise in several directions—if one may put the matter so unscientifically. There is no need to lift its cones on a long, slowly developed stem in order to bring them into a position favourable to the action of the wind, which its habitat would demand. As a consequence the age of cone production is probably reached much earlier—a point confirmed by the comparative growth of young plants of this and other species. There is also evidence that a considerable reduction both in the number of microsporophylls and sporangia has taken place. Complete records have not yet been obtained, but the number of both these organs is certainly much smaller than in such forms as *E. latifrons* and *E. Friderici Guilielmi*, both of which grow in open grassland.

Without access to the literature of the Cycadaceæ it is impossible to say to what extent the arrangement of the sporophylls with downward imbrication prevails in the family, and therefore to what extent it indicates an entomophilous condition. It is at least interesting that our three species differ so markedly in a feature of this nature, which must of necessity be closely related to their pollination.

E. Altensteinii appears to represent an intermediate condition wherein both forms of pollination are possible. In the colouring of the staminate cone, in the odour emitted by it, and in the arrangement of the sporophylls it stands almost midway between Stangeria and *E. villosus*. Have insects of the Phlæophagus type more recently extended their operations to *E. Altensteinii* than *E. villosus*? If this question could be answered in the affirmative, would it not help us to understand how this species is being fitted to leave the open wind-swept krantz for the shelter of the wooded kloof?

Most of the points have been discussed with Professor Pearson of the South African College, and I would like to take this opportunity of acknowledging that the observations were begun under his inspiration and continued with his unwearying advice and assistance.

NOTE ON AN OVERLOOKED THEOREM REGARDING THE PRODUCT OF TWO DETERMINANTS OF DIFFERENT ORDERS.

By Thomas Muir, LL.D.

(Received January 8, 1913.)
(Read April 16, 1913.)

1. Hidden away in an investigation on the common roots of two equations (*Comptes Rendus . . . Acad. des Sci.* (Paris), lxxxviii, pp. 223–224), there occurs the following theorem :—

" *Soient* $A = \Sigma \pm a_{11}a_{22} \ldots a_{mm}$ *et* $B = \Sigma \pm b_{11}b_{22} \ldots b_{nn} (m > n)$ *deux déterminants : si l'on désigne par* B_{ks} *le résultat de la substitution des* n *premiers éléments de la* $k^{ième}$ *ligne de* A *à la place de la* $s^{ième}$ *ligne de* B, *par* α_{ir} *les mineurs de* A *par rapport au* $r^{ième}$ *colonne et par* β_{kr} *le mineur de* B *par rapport au* $r^{ième}$ *élément de la* $k^{ième}$ *ligne, on a identiquement—*

$$\alpha_{1r}B_{1k} + \alpha_{2r}B_{2k} + \ldots + \alpha_{mr}B_{mk} = A\beta_{kr},$$

en considérant β_{kr} *comme nul quand* r *est plus grand que* n."

No proof is given, and it is consequently a little difficult to see how the author came to reach a result of such importance without obtaining a much more extensive generalisation.

2. A brief scrutiny suffices to convince one that what the theorem really gives is an expression for the product of any two determinants of the pth and qth orders $(p > q)$ in the form of a sum of products of two determinants of the $(p-1)$th and $(q+1)$th orders. It is at once clear, for example, that the kth row of B in the identity is a fiction, for on the left-hand side it is explicitly supplanted by rows obtained from A, and on the

right-hand side it and the rth column of B are simultaneously excluded. Thus, taking the case

$$m,\ n,\ k,\ r = 4,\ 3,\ 3,\ 3$$

we have

$$|a_{21}\ a_{32}\ a_{44}| \cdot \begin{vmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ a_{11} & a_{12} & a_{13} \end{vmatrix} - |a_{11}\ a_{12}\ a_{44}| \cdot \begin{vmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ a_{21} & a_{22} & a_{23} \end{vmatrix}$$

$$+ |a_{11}\ a_{22}\ a_{44}| \cdot \begin{vmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ a_{31} & a_{32} & a_{33} \end{vmatrix} - |a_{11}\ a_{22}\ a_{34}| \cdot \begin{vmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ a_{41} & a_{42} & a_{43} \end{vmatrix}$$

$$= |a_{11}\ a_{22}\ a_{33}\ a_{44}| \cdot |b_{11}\ b_{22}|,$$

where neither on the one side nor on the other do the elements b_{31}, b_{32}, b_{33} (that is to say, the third row of B) occur. As a matter of fact there are only four elements of B found on both sides: and it is the introduction of the two extra elements b_{13}, b_{23} which makes the identity possible.

3. The following mode of establishing the theorem in the foregoing particular case throws additional light on the point raised.

The right-hand member of the identity is clearly equal to

$$\begin{vmatrix} a_{11} & a_{12} & a_{13} & a_{14} & \cdot & \cdot \\ a_{21} & a_{22} & a_{23} & a_{24} & \cdot & \cdot \\ a_{31} & a_{32} & a_{33} & a_{34} & \cdot & \cdot \\ a_{41} & a_{42} & a_{43} & a_{44} & \cdot & \cdot \\ b_{11} & b_{12} & b_{13} & \cdot & b_{11} & b_{12} \\ b_{21} & b_{22} & b_{23} & \cdot & b_{21} & b_{22} \end{vmatrix}$$

which, again, by subtraction of the first two columns from the last two columns is equal to

$$\begin{vmatrix} a_{11} & a_{12} & a_{13} & a_{14} & -a_{11} & -a_{12} \\ a_{21} & a_{22} & a_{23} & a_{24} & -a_{21} & -a_{22} \\ a_{31} & a_{32} & a_{33} & a_{34} & -a_{31} & -a_{32} \\ a_{41} & a_{42} & a_{43} & a_{44} & -a_{41} & -a_{42} \\ b_{11} & b_{12} & b_{13} & \cdot & \cdot & \cdot \\ b_{21} & b_{22} & b_{23} & \cdot & \cdot & \cdot \end{vmatrix},$$

and the expansion of this by means of Laplace's theorem gives the left-hand member.

Had we omitted the elements b_{13}, b_{23} on starting, the result would have been nugatory, namely—

$$|a_{11}\ a_{22}\ a_{33}\ a_{44}| \cdot |b_{11}\ b_{22}| = |b_{11}\ b_{22}| \cdot |a_{13}\ a_{24}\ a_{31}\ a_{42}|.$$

If on the other hand we had in addition inserted b_{14}, b_{24} we should have obtained for

$$|a_{11}\ a_{22}\ a_{33}\ a_{44}| \cdot |b_{11}\ b_{22}|$$

an expression consisting of six terms of a similar form beginning with

$$\begin{vmatrix} a_{11} & a_{12} & a_{13} & a_{14} \\ a_{21} & a_{22} & a_{23} & a_{24} \\ b_{11} & b_{12} & b_{13} & b_{14} \\ b_{21} & b_{22} & b_{23} & b_{24} \end{vmatrix} \cdot \begin{vmatrix} a_{31} & a_{32} \\ a_{41} & a_{42} \end{vmatrix}.$$

4. It is thus evident that the product of two determinants of the pth and qth orders is expressible as a sum of products of two determinants: (1) of the $(p-1)$th and $(q+1)$th orders, (2) of the $(p-2)$th and $(q+2)$th orders, (3) of the $(p-3)$th and $(q+3)$th orders, and so on, the number of results being $p-q$.

In Sylvester's similar theorem, which has received every attention from writers of text-books, q is equal to p, and the orders of the determinant factors in the expansion are the same as those in the original product.

Of course any one of the expansions obtained for the given product can be equated to any other, and there is thus originated a series of identities similar to Schweins' of 1825 (see *Philos. Magazine*, xviii (1884), pp. 416–427).

A SYNOPSIS OF THE SPECIES OF *LOTONONIS*, Eckl. and Zeyh., and *PLEIOSPORA*, Harv.

By R. A. Dümmer.

(Received November 13, 1912.)

(Communicated by H. H. W. Pearson.)

(Read April, 1913.)

(Plate XIX.)

Since Harvey's excellent systematic account in the Flora (Flora Capensis, II. pp. 47–66) of the genera here alluded to, a considerable bulk of undetermined material appertaining to these groups has accumulated, which has suggested the expediency of the following paper. This aims at a segregation of all known species and their identification by the aid of appended keys. The material examined has been particularly rich in type specimens, especially at Kew, which has considerably facilitated the work, while that of the British Museum and the Edinburgh Botanic Gardens, has augmented the list of collectors' numbers and incidentally assisted in clearing up several critical points.

Dr. H. Schinz, of the University of Zürich, has courteously forwarded the material relating to these genera for examination, among which I have to record several species new to science. Through the kindness of Dr. H. Dixon, of Trinity College, I was permitted to examine Harvey's type of *L. Wrightii*, which has confirmed my suspicions as to its correct status and suggested its transference to *Hallia*. Dr. O. Juel, of Upsala, with his customary courtesy, has forwarded information regarding Thunberg's types, and after a critical examination of a flower of *Lebeckia densa*, Thunberg, which species was referred by Harvey to *Lotononis*, I am unable to accept the latter author's view and follow Thunberg in his conception of that species.

To the authorities of the institutions here alluded to, my thanks are due for access to specimens and the literature thereto, nor can I fail to acknowledge the assistance rendered by Mr. A. J. Jennings at the commencement of the work, which he had to subsequently relinquish, owing to an appointment abroad.

The genera *Lotononis,** Ecklon and Zeyher, and *Pleisopora,* Harvey, constitute groups of the Order Leguminosae, which were assigned a position by Bentham intermediate between *Lebeckia* and *Aspalathus,* on the one hand, and *Rafnia* on the other, in the tribe Genisteae. As a brief review of each genus precedes the enumeration of its species, it will only be necessary to tabulate the differences distinguishing these genera.

Carina curved. *Style* curved,† not geniculate = *Lotononis.*
Carina straight. *Style* straight, in line with the ovary.‡ = *Pleiospora.*

LOTONONIS, Ecklon and Zeyher, Enum. Pl. 176 (1835).

The genus *Lotononis,* numbering approximately 108 species, displays considerable superficial polymorphism, as may be inferred by the fact that prior to Bentham's conception of the genus, the species then known were scattered over seven genera, but subsequently the author alluded to, recognising the uniformity of the more salient characters, reduced these to sections, which, on the whole being perfectly natural, were adopted (and slightly amplified) by Harvey, and are accepted here, with the exception of the § *Oxydium,* whose units (owing to the presence of a rostrate carina and its correlated genuflexed style), exhibit a greater affinity to the genus *Crotalaria,* to which they are consequently referred. The expediency of this step is apparent, when a close study of the calyx of either of the genera is instituted, and contrasting points, which have been considered of great import by systematists, are recognised to be variable to both groups; § hence the necessity of seizing upon more stable characters of which the absence or presence respectively of the rostrum in this instance appears to be the most satisfactory point of distinction, the turgidity of the pods being peculiar to both genera and therefore a point of secondary importance. Similarly to emphasise the stability of the genus under consideration, and to obviate any overlapping, certain recently described species of *Lotononis* have been referred to *Pearsonia, mihi,*‖ while *Buchenroedera*

* This genus is ascribed by some authors to De Candolle, who, despite its authorship, used it, however, only in a sectional sense; it was subsequently raised to generic rank by Ecklon and Zeyher.

† This character is dependent upon the relative age of the flower; after fertilisation the style often assumes a different shape.

‡ Cf. *Journal of Botany*, Nov. (1912), 353–358.

§ Mr. E. Baker, who is engaged on a monograph of the African *Crotalarias* is disposed to agree with me in this matter.

‖ Cf. *Journal of Botany*, Nov. (1912), 353–358.

biflora, Bolus, and *Lebeckia leucoclada*, Schlechter, are intercalated with the former genus.

Although it is conceded that the calycine characters seized upon by most authors hold good in the majority of cases, nevertheless an examination of *Buchenroedera lotononoides*, Scott Elliot, reveals every gradation from a *Lotononis* to a *Buchenroedera* calyx, and precisely so in *Lotononis Woodii*, Bolus, where a leaning to an *Argyrolobium* calyx also obtains. These facts lead to the conclusion that until more fruiting material is obtainable, and differences based upon the nature of the fruits and their contents are ascertained, these genera and those in the vicinity must remain to some extent unnatural, and be arbitrarily accepted.

The sectionising of the genus is largely based upon the disposition of the flowers and incidentally often in correlation with the habit of the species, which are occasionally annuals, perennial, decumbent or procumbent plants, or, as in the sections, *Krebsia* and *Aulacinthus*, rigid shrublets. The annuals are more or less confined to the Western Region of the Cape Colony in Little Namaqualand, where this phase of vegetation is one of the most striking floral points in the physiognomy of that region, the early rains being almost instantaneously followed by a profusion of gaily coloured annuals, to which a striking contrast is furnished by the prolonged drought which follows, when almost every sign of vegetation disappears.

The genus is essentially South African, about 100 of the 108 species constituting the genus being confined to that region, while the remainder extend into the Tropics via the Eastern Coast, thence into Abyssinia, Morocco, and Arabia, *L. Leobordea*, Benth., being the most widely diffused species from Cape Colony to Southern Persia and Baluchistan; its claim to be a native of South Africa is, however, very problematical.

The species endemic in South Africa are, as far as Herbaria material suggests, fairly local and well defined, but where a wider diffusion than usual obtains, the species is marked by a variability exceedingly perplexing to the systematist. The § *Aulacinthus*, comprising four species is confined to the Western Coastal Region of Cape Colony, extending from Little Namaqualand south-eastwards to the Uitenhage Division, the highest northerly point on the western coast of Africa being attained by *L. angolensis*, Welwitsch. The species appertaining to the § *Krebsia* (which section, by the inclusion of several novelties, requires extension), are more or less coastal in their distribution, commencing from the Caledon Division in the south-western strip of Cape Colony, and gradually extend eastwards, still hugging the coast, to Natal, from whence they diffuse inland over the Drakensbergen to the Transvaal. *L. digitata*, Harvey, and *L. Benthamiana*, Dümmer, species peculiar to Little Namaqualand, exhibit considerable deviation from the remaining members of this section, by their quinquefoliolate leaflets and shortly stipitate legumes, but it appears best to follow Harvey's view as regards their inclusion in that section.

In their habit, the representatives of the § *Telina* differ markedly from those of the preceding section in being diffuse or decumbent perennial herbs, with slender peduncled one- or few-flowered inflorescences, the species preponderating in the South-West Region of the Colony, and suddenly reappearing northwards in the Transvaal. The latter group comprises five species, two of which bear smaller yellow flowers, and subfalcate-torulose legumes.

The approximation of the remaining species of the § *Oxydium* to § *Polylobium*, a section showing slight overlapping to the § *Telina* is considered here, to facilitate comparison of the remaining sections. The species are also more or less coastal in their distribution and coincide with that of the members of the § *Telina*, except in extending farther eastwards up to Port Elizabeth and Albany, reappearing in Angola and East Central Africa.

§ *Lipozygis* has a wider diffusion, the group comprising prostrate or decumbent herbs, occasionally annuals, with lateral subsessile globose flower-heads, occurring in Little Namaqualand to Tulbagh, in the Western and South-Western Coastal Region of the Colony, while the remaining species, exclusively perennial, with terminal hemispheric inflorescences, are Eastern and Central in their distribution, preponderating in the Griqualand East, Natal and Transvaal Provinces respectively.

In the minute abaxial tooth of the calyx, the peculiarly curved carina and the almost tubular calyx, the four species constituting the section *Leobordea*, depart somewhat from the general type of the genus, and a more critical investigation of the group may suggest their separation; their distribution is Coastal and Central, they being entirely absent from the Eastern Region.

§ *Leptis* represents a large and heterogeneous group whose species total about forty-five; their sequence here is not quite in accord with that of Harvey, as the disposition and nature of the indumentum of the leaflets has been found to be in correlation with their natural diffusion, upon which their sequence is therefore based. In this section a small group of three species mimicking in habit those of § *Krebsia*, with quinquefoliolate leaves, yellow flowers, and shortly stipitate legumes obtain, which are confined to Little Namaqualand, while one occurs in Algeria and Spain. The remainder of the section are more ubiquitous, preponderating in Cape Colony, and extending via the East Coast to North Africa in Morocco. To facilitate the identification of recently described species a brief sketch of the sections as proposed by Bentham, but slightly modified to suit present exigencies plus a clavis to the individual genera, is appended.

§ 1. AULACINTHUS, Bentham, Hook. London, Jour. Bot. II. (1843), 596.

Racemes terminal, prolonged. *Legume* turgid with a sunken ventral suture.

Rigid shrublets. *Leaves* trifoliolate ; stipules minute, solitary or absent. *Aulacinthus*, E. Meyer, Comment. Pl. Afr. Aust. 156 (1835).

§ 2. KREBSIA, Bentham, l.c.

Flowers solitary, in pairs or few together, subsessile or shortly pedicellate, axillary or terminating short lateral branchlets (rarely terminal or racemosely disposed). *Legume* compressed, without a sunken ventral suture, sessile or shortly stipitate.

Rigid shrublets, with subsimple ascending rod-like branches (rarely divaricately branched), or with a persistent woody rootstock from which annual subsimple erect flowering branches develop. *Leaves* tri- to quinquefoliolate ; stipules solitary or in pairs, foliaceous. *Krebsia*, Ecklon and Zeyher, Enum. Pl. 179 (1835).

§ 3. TELINA, Bentham, l.c.

Flowers solitary or few, subumbellately terminating elongated peduncles. *Carina* obtuse. *Legumes* straight or turgid, or compressed and falcate-subtorulose.

Diffuse or decumbent undershrubs or herbs. *Leaves* trifoliolate ; stipules solitary or in pairs, foliaceous. *Telina*, E. Meyer, l.c. 67.

§ 4. POLYLOBIUM, Bentham, l.c.

Inflorescence pedunculate, umbellate. *Carina* obtuse or acute. *Legume* straight, compressed or turgescent.

Diffuse or rarely suberect suffruticose-herbaceous plants. *Leaves* trifoliolate ; stipules solitary or in pairs. *Polylobium*, Ecklon and Zeyher, l.c. 176.

§ 5. LIPOZYGIS, Bentham, l.c. 596.

Inflorescence subsessile ; flowers disposed in terminal or lateral, hemispheric or globose heads.

Diffuse or decumbent herbs (occasionally annual), or with a perennial woody roostock sending up subsimple, erect, leafy, annual, flowering shoots. *Leaves* trifoliolate, rarely quinquefoliolate ; stipules solitary or none, foliaceous. *Lipozygis*, E. Meyer, l.c. 76.

§ 6. LEOBORDEA, Bentham, l.c. 597.

Flowers solitary, subsessile, opposite the leaves or few together in the forks of the stems. Lower calyx-segment much shorter than the remaining two pairs. Limb of the carina narrowly oblong, shortly geniculate, rotundate.

Small prostrate, dichotomously branched herbs or undershrubs (occasionally annual). *Leaves* trifoliolate; stipules minute. *Leobordea,** Délile in Laborde, Voy. Arab. 86. *Leobardea,* Pomel, Nuov. Mat. Fl. Atlas, 162 (1874). *Capnitis,* E. Mey. l.c. 81.

§ 7. LEPTIS, Bentham, l.c. 597.

Flowers solitary, or in few-flowered subsessile clusters, subsessile or pedicellate, opposite the leaves or terminating short twigs (rarely subumbellately disposed). Lower calyx-segment equalling or longer than the remaining two pairs. Limb of the carina obliquely boat-shaped, acute or obtuse.

Diffuse (rarely erect), undershrubs (occasionally annuals). *Leaves* trifoliolate (rarely quinquefoliolate or unifoliolate); stipules solitary or in pairs. *Leptis,* E. Meyer ex Ecklon and Zeyher, Enum. Pl. 174. *Leptidium,* Presl. Bot. Bemerk. 49.

§ 1. AULACINTHUS.

I. Leaves exstipulate. Flowers 8–11 mm. long.
  *Leaflets obcordate or broadly cuneate, 3·5–5 mm. broad, truncate or emarginate. .. .. (2) *leucoclada.*
  **Leaflets oblanceolate or cuneate, 1·5–2·5 mm. broad, subacute.
    Racemes 5–10-flowered; calyx sericeous. .. .. (1) *gracilis.*
    Racemes few-flowered; calyx with spreading hairs .. (3) *rigida.*
II. Leaves stipulate; stipule foliaceous.
    Flowers small, scarcely exceeding 6 mm. .. .. .. (4) *viborgioides.*

§ 2. KREBSIA.

I. Leaves trifoliolate. Legume sessile.
  A. Vexillum ample, with an orbicular or reniform limb. Flowers bluish or purplish.
    a. Leaflets glabrous, linear-lanceolate, pungent or subacicular.. .. .. (8) *carnosa.*
    b. Leaflets sericeous or patently and shortly strigillose, oblanceolate or broadly cuneate.
      1. Plant a light green. Leaflets with thickened margins. Peduncle invariably 2-flowered.. (6) *biflora.*
      2. Plant a greyish green or silvery. Leaflets with unthickened margins. Peduncle invariably 1-flowered. Vexillum often sericeous posticously.
        *Stipules in pairs.
          †Entire plant silvery. Vexillum very shortly clawed; limb 12–15 mm. in diameter, densely sericeous posticously. (7) *Wyliei.*

* Despite the priority of this name it does not appear desirable to resuscitate it.

††Entire plant greyish green. Vexillum with a longish claw; limb 8–10 mm. in diameter, glabrous or slightly sericeous posticously on the upper half. .. .. (5) *cytisoides.*

**Stipules solitary.

†Plant sparingly sericeous. Twigs sparingly leafy, slender and subsimple.

Legume sericeous. .. .. (9) *divaricata.*

Legume patently pubescent. .. .. (10) *sericophylla.*

††Plant densely and shortly greyish strigillose. Twigs densely leafy and short. .. .. (11) *Galpinii.*

B. Vexillum spathulate with an oblong subacute limb. Flowers yellowish or rose-red.

Corolla glabrous, yellowish. Pedicels 2–3 mm. long. (12) *dichiloides.*

Corolla sericeous, rosy red. Flowers very shortly pedicellate.

Leaves densely imbricate; twigs hirsute. .. .. (13) *hirsuta.*

Leaves shorter than the internodes; twigs inconspicuously sericeous.

Inflorescence 3–6-flowered. Leaflets glabrous on the upper surface. .. .. (14) *transvaalensis.*

Flowers invariably solitary. Leaflets sericeous on both surfaces. .. .. (15) *pauciflora.*

II. Leaves preponderatingly quinquefoliolate. Flowers straw-coloured. Legume shortly stipitate.

Petiole much shorter than the leaflets. Limb of the carina narrowly oblong, 3 mm. wide. .. .. (16) *digitata.*

Petiole equalling the terminal leaflet. Limb of the carina broadly boat-shaped, 5 mm. wide. .. .. .. (17) *Benthamiana.*

§ 3. TELINA.

I. Legume straight and turgescent. Vexillum exceeding the carina in length.

A. Vexillum not reflexed. Bracts and bracteoles obovate. Peduncle not exceeding 1 cm. in length. .. .. .. (18) *bracteata.*

B. Vexillum reflexed and ample. Bracts and bracteoles subulate or lanceolate. Peduncle slender, 2–10 cm. long.

a. Vexillum either with a posticous longitudinal line of hairs or pubescent on the upper half.

*Vexillum pubescent on the upper half posticously.

Leaflets glabrous on the upper surface at maturity.

Plant small, compact. Flowers small. Limb of the vexillum 8 mm. across. .. (20) *minor.*

Plant large, diffuse. Flowers large. Limb of the vexillum 1–1·5 cm. across. .. .. (19) *azurea.*

Leaflets with short bristle-like hairs on both sides; conspicuously netted on the under surface. .. .. (24) *acuminata.*

Leaflets densely covered on both sides with long silky hairs; not reticulate on the under surface.
Leaflets cuspidate. Calyx subequalling the vexillum. .. .. (23) *villosa.*
Leaflets acute or acuminate. Calyx shorter than the vexillum. .. .. .. (25) *argentea.*
**Vexillum with a median longitudinal line of hairs posticously.
Peduncle invariably 1-flowered. Leaflets appressedly and shortly strigillose on the lower surface. .. .. (21) *prostrata.*
Peduncle usually 2–4-flowered. Leaflets entirely glabrous. .. .. (26) *varia.*
b. Vexillum entirely glabrous.
Leaflets broadly obovate-cuneate or suborbicular, glabrous. Plant drying black.
Peduncle slender, 1-flowered. Plant entirely glabrous.. .. .. (27) *solitudinis.*
Peduncle stout, 3–4-flowered. Plant inconspicuously pubescent. .. .. (28) *macrocarpa.*
Leaflets linear, acute, pilose.
Plant not drying black. .. .. (22) *macra.*
II. Legume subfalcate, compressed and subtorulose. Vexillum shorter than the carina.
*Stipules large, ovate-cuspidate, invariably equalling or exceeding the petiole. Twigs patently hirsute.. .. .. (31) *magnistipulata.*
**Stipules minute, much shorter than the petiole. Twigs puberulous or glabrescent.
Compact. Peduncle 1-flowered. Leaflets oblanceolate or obovate, 4–10 mm. long.. .. .. (29) *Marlothii.*
Diffuse. Peduncle 2–5-flowered. Leaflets narrowly elliptic, 5–40 mm. long. .. .. (30) *Barberae.*

§ 4. POLYLOBIUM.

I. Carina rounded or obtuse.
A. Stem diffuse or decumbent, often branched.
a. Leaflets broadly obovate-cuneate or elliptic; stipules solitary.
Corolla densely sericeous. Leaflets elliptic .. (33) *procumbens.*
Corolla glabrous. Leaflets broadly obovate-cuneate.
Bracts subulate, minute.
Calyces with inconspicuous appressed hairs. .. .. (32) *umbellata.*
Calyces with conspicuous spreading hairs. (34) *debilis.*
Bracts obovate or orbicular, longer than the pedicel. .. .. (36) *pallens.*
b. Leaflets linear lanceolate, broadly oblanceolate or narrowly elliptic.
*Vexillum small, shorter than the carina, glabrous. Stipules solitary.
Stipules subulate or lanceolate-acute. Flowers nodding. Calyx glabrescent. .. (37) *angolensis.*

Stipules ovate-cuspidate. Calyx pubescent. (38) *Bainesii.*
**Vexillum ample, exceeding the carina. Stipules in pairs.
†Plant entirely glabrous. Vexillum glabrous.
Leaflets narrowly obovate-cuneate. .. .. (35) *Bachmanniana.*
††Plant with spreading hairs. Vexillum with a median longitudinal line of hairs posticously. Leaflets lanceolate, oblanceolate, or narrowly elliptic.
Flowers nodding. Peduncle terminal.
Calyx appressedly pubescent. .. .. (41) *peduncularis.*
Calyx with spreading hairs. .. .. .. (40) *tenuifolia.*
Flowers aggregated in globose or hemispheric hairy heads, which invariably terminate short lateral twigs .. .. (39) *involucrata.*
B. Stem ascending or erect, simple. Leaflets linear, pungent.
Flowers pedicellate. Vexillum ample, reflexed, slightly sericeous posticously. .. .. (42) *angustifolia.*
Flowers subsessile. Vexillum small, hidden by the calyx. Corolla with spreading hairs. .. .. .. (43) *Newtoni.*
II. Carina acute.
Leaves unifoliolate. Leaflets ovate. Peduncle 3-flowered. Vexillum sericeous posticously. .. .. .. (45) *monophylla.*
Leaves trifoliolate. Leaflets obovate. Peduncle 4–many-flowered. Vexillum entirely glabrous. .. .. (44) *trichopoda.*

§ 5. LIPOZYGIS.

I. Prostrate or decumbent herbs (often annuals). Flower-heads globose, lateral or terminal.
A. Leaves preponderatingly 5-foliolate.
a. Flowers white. Calyx densely and softly pilose.
Leaflets glabrous on the upper surface at maturity.
Bracts conspicuous, ovate-cuspidate. .. .. (49) *anthylloides.*
Bracts subulate or lanceolate, acute.
Leaflets subcoriaceous. Calyx 6 mm. long. (46) *pentaphylla.*
Leaflets with hairs on both surfaces.
Leaflets thin-textured. Calyx 7–8 mm. long .. .. (50) *Bolusii.*
b. Flowers rose-coloured. Calyx stiffly strigillose.
Leaflets herbaceous, sparingly pilose on both sides. .. .. (47) *rosea.*
B. Leaves always trifoliolate.
Leaflets coriaceous, densely hirsute-sericeous on both surfaces. .. .. (48) *polycephala.*
II. Plants developing usually erect, annual, flowering, subsimple shoots from a woody perennial rootstock. Flower-heads hemispheric, invariably terminal.
A. Plant not drying black.
*Corolla sericeous.
*i*Stipules in pairs.
Leaflets linear-acute, 5 mm. long. .. .. .. (51) *Wilmsii.*

*ii*Stipules solitary.
Twigs and leaflets shortly pubescent, the former terete; terminal leaflet 5–10 mm. long. .. .. (52) *Sutherlandii.*
Twigs and leaflets hirtellous or densely hirsute, obovate-cuneate, the former angulate; terminal leaflet elliptic, 10–15 mm. long, 4–7 mm. broad, subacute (rarely broadly obovate).
Vexillum 4 mm. broad, auriculate at the base. (53) *eriantha.*
Vexillum 2·5–3 mm. broad, attenuate at the base. .. .. (55) *corymbosa.*
**Corolla glabrous, except for a median longitudinal posticous line of deciduous hairs on the limb of the vexillum. .. .. (54) *pulchra.*
B. Plant drying black.
†Stipulate. Flower-heads rarely exceeding 3 cm. in diameter.
Carina 4 mm. broad.. .. .. (57) *foliosa.*
Carina 2 mm. broad.. .. .. (56) *lanceolata.*
††Exstipulate. Flower-heads exceeding 4 cm. in diameter, compactly 25–30-flowered.. .. .. .. (58) *grandis.*

§ 6. LEOBORDEA.

*Carina 14 mm. long.
Petioles 6–8 mm. long, the leaflets slightly shorter; stipule solitary, falcate .. .. (59) *carinalis.*
**Carina 9 mm. long. Calyx subinflated and prominently nervate at the maturation of the fruit. Caespitose .. .. (60) *Steingroeveriana.*
***Carina 4–7 mm. long. Calyx not inflated, prominently nervate. Dichotomously branched and spreading, rarely caespitose.
Calyx 6 mm. long, shortly pubescent .. .. (61) *clandestina.*
Calyx 3–4 mm. long, sericeous or villous .. .. (62) *Leobordea.*

§ 7. LEPTIS.

I. Leaves preponderatingly 5-foliolate. Legume very shortly stipitate.
a. Flowers large, exceeding 2 cm.; vexillum much shorter than the carina. Leaflets thickly coriaceous (66) *longiflora.*
b. Flowers small, not exceeding 1 cm.; vexillum subequalling the carina.
Petioles averaging 1–1½ cm. Legume glabrous .. (64) *delicatula.*
Petioles 5 mm. long. Legume inconspicuously sericeous.
Carina narrow, 1 mm. Corolla glabrous .. .. (63) *quinata.*
Carina broad, 2–3 mm. Corolla sericeous .. .. (65) *lupinifolia.*
II. Leaves trifoliolate, rarely unifoliolate. Legume sessile.
A. Leaflets sericeous on both sides (rarely patently hirsute).
*Carina acute.
†Pod included within the calyx.
Stipules cordate-ovate. Bracts involucrate, conspicuous, broadly subreniform .. .. .. (67) *Burchellii.*

Stipules lanceolate, subacute. Bracts inconspicuous, subulate.

Flowers in fascicles of 2–6. Stipules foliaceous, sericeous.. .. .. (68) *crumanina.*

Flowers solitary. Stipule minute, very hairy (69) *maculata.*

††Pod extruding from the calyx.

Leaflets narrowly elliptic or oblanceolate, acute, ½–2½ cm. long, 2–3 mm. broad. .. .. (70) *laxa.*

Leaflets elliptic or obovate, subacute or rounded, 7–12 mm. long, 4–5 mm. broad.. .. .. (71) *Woodii.*

**Carina obtuse.

†Calyx as long as the carina or exceeding it.

Leaflets sericeous, coriaceous. Vexillum slightly sericeous, 9–15 mm. long.

Terminal leaflet 2½ cm. long. Calyx 1½ cm. long. .. .. (73) *macrosepala.*

Terminal leaflet 1½ cm. long. Calyx ¾ cm. long. .. .. (72) *humilior.*

Leaflets patently hirsute, thin-textured.

Leaflets 1 cm. long. Vexillum glabrous, 4–5 mm. long. .. .. (74) *desertorum.*

††Carina exceeding the calyx.

*Leaflets ferruginously sericeous or thickly hirsute-sericeous.

*i*Pedicels slender, ½–1½ cm. long, patently spreading. Leaflets linear-lanceolate, acuminate, 1–2 cm. long. .. .. (75) *uniflora.*

*ii*Flowers subsessile or shortly pedicellate.

a. Flowers subsessile. Vexillum narrow, 3–3½ mm. broad. Twigs with spreading hairs.

Leaflets obovate-oblanceolate-cuneate, obtuse or subacute, 4–6 mm. long. Carina 7–8 mm. long.

Flowers in pairs or threes. Leaflets densely sericeous. .. .. (79) *sericoflora.*

Flowers solitary. Leaflets densely hirsute-sericeous. .. .. (78) *adpressa.*

Leaflets linear elliptic, acuminate, 1–2 cm. long. Carina 1 cm. long. Flowers 2–5-fascicled.. .. .. (76) *Dinteri.*

b. Pedicels 3 mm. long. Vexillum broad, 4–5 mm. Twigs sericeous. .. .. (77) *mollis.*

**Leaflets silvery, shortly and sparingly sericeous.

a. Flowers whitish to brownish. Legume sericeous.

†Carina densely sericeous or pubescent. Always perennial.

Vexillum 1½ cm. long. Calyx 5–7 mm. broad, its nerves prominent. Stipules oblanceolate-cuneate.. .. .. (80) *maroccana.*

Vexillum 7–8 mm. long. Calyx 3–4 mm. broad, its nerves obsolete. Stipules lanceolate-acute. .. .. (81) *genistoides.*

††Carina glabrous. Often annuals.
Legume 12–18 mm. long, flattened. Leaflets obovate, oblanceolate, or narrowly elliptic.
Legume 3 mm. broad, often falcate.
Flowers invariably solitary. .. .. (83) *falcata.*
Legume 4 mm. broad, always straight.
Flowers solitary. .. .. (84) *leptoloba.*
Flowers in 2's to 6's .. .. (82) *brachyloba.*
Legume 7–9 mm. long, turgescent. Leaflets broadly obovate-cuneate or obcordate-cuneate. .. .. (86) *pumila.*
b. Flowers blue. Legume hirtellous. .. .. .. (85) *Maximiliani.*
B. Leaflets glabrous or glabrescent on the upper surface.
*i*Limb of the carina ample, suborbicular or broadly triangular, reflexed exceeding the carina.
Leaflets linear elliptic, pungent. Vexillum with a median posticous longitudinal line of hairs.
Petiole averaging 4 mm. long. Legume sericeous. .. .. (89) *depressa.*
Petiole averaging 10 mm. long. Legume patently pubescent. .. .. (91) *pungens.*
Leaflets oblanceolate, rounded, truncate or emarginate. Vexillum entirely glabrous. .. .. .. (90) *flava.*
*ii*Vexillum spathulate ; limb oblong, shorter than the carina or subequalling it.
a. Carina entirely glabrous.
*Carina acute. Legume turgid.
Leaflets and calyces patently hairy. .. (92) *tenella.*
Leaflets and calyces more or less sericeous. (94) *versicolor.*
**Carina obtuse or rotundate. Legume compressed.
*i*Leaflets elliptic. Flowers 7 mm. long.
Perennial. Leaflets 4–5 mm. long. .. (100) *mucronata.*
Annual. Leaflets 10–20 mm. long. .. (87) *rara.*
*ii*Leaflets linear, 2 cm. long. Flowers 4 mm. long. .. .. (88) *tenuis.*
*iii*Leaflets obovate-cuneate.
Carina not exceeding 5 mm. long. Leaflets coriaceous, with a thick dorsal midrib .. .. (95) *neglecta.*
Carina 6–10 mm. Leaflets thinly coriaceous, with the dorsal midrib only prominent towards the base.
Carina 6–7 mm. long. Prostrate or diffuse, much-branched and slender. Flowers few. .. .. (101) *Gerrardii.*
Carina 9–10 mm. long. Decumbent, sparingly branched, floriferous. .. .. (104) *ornata.*
b. Carina sparingly sericeous in front, or invested with small deciduous hairs.
*i*Calyx nearly as long as the carina or exceeding it.
Twigs and calyces villous.

Seeds brick-red. Legume flattened, exceeding the calyx. .. .. (107) *calycina.*
Seeds pale brown. Legume turgid, 8 mm. long, usually included within the calyx.. .. .. (93) *orthorrhiza.*
Twigs and calyces sericeous. Pod turgescent, included within the calyx, 5–6 mm. long. .. .. (106) *ambigua.*
ii Calyx much shorter than the carina.
Calyx patently pubescent. Carina 1 cm. long. .. .. (103) *Rehmannii.*
Calyx sericeous.
†Carina 5–6 mm. long.
*Twigs white-tomentellous. Limb of the vexillum slightly sericeous above on the dorsal side.
Calyx 2–3 mm. long. .. .. (98) *arida.*
**Twigs sericeous. Limb of the vexillum entirely sparingly sericeous posticously. Calyx 4–5 mm. long.
Carina reflexed. .. .. (99) *pusilla.*
Carina not reflexed. .. .. (108) *Dregeana.*
††Carina 7–10 mm. long.
Plant silvery. Flowers small, pale cream. Limb of the vexillum with a median longitudinal posticous line of hairs. .. .. (105) *microphylla.*
Plant seemingly glabrescent. Flowers large, ochreous. Limb of the vexillum entirely pubescent dorsally. .. .. (102) *humifusa.*

c. Carina densely sericeous all over.
Flowers solitary, few. Branches subsimple, prostrate or decumbent. Leaflet-margin thickened. .. .. (96) *carinata.*
Flowers invariably in fascicles of 2's to 6's. Divaricately-branched, diffuse. Leaflet-margin unthickened .. .. (97) *florifera.*

§ 1. AULACINTHUS.

1. L. GRACILIS, Bentham in Hook. Lond. Jour. Bot. II. 597 ; Harvey in Harv. and Sond. Fl. Cap. II. 50. *Aulacinthus gracilis*, E. Meyer, l.c. 156. *Buchenroedera Meyeri*, Presl. Bot. Bemerk. 49.

South Africa. Western Region. Little Namaqualand: Roode Berg, 750–1050 m., *Drège a !* Ezelsfontein and Roode Berg, 1050–1200 m., *Drège b !* Little Namaqualand, *Scully*, 167 ! Herb. Norm. Aust.-Afr. 1125 ! Coast Region. Clanwilliam Div.: On the Koudeberg, Cederbergen near Wupperthal, 720 m., *Bolus*, 8971 !

Var. ANOMALA, Harvey, l.c.

Little Namaqualand: Kamies Bergen, *Pappe*, 100.

This variety is not represented at Kew or the British Museum; it is reputed to differ from the type in the relatively longer pods.

Var. BREVIPETIOLATA, Dümmer and Jennings, var. nova. A typo foliis brevipetiolatis, racemis laxe multifloris recedit.

Petioles 0·3–0·5 cm. long. *Racemes* laxly 7–10-flowered; *calyx* sparsely silky or almost glabrescent.

In its other characters this variety conforms to the type, differing only in the shortly petiolate leaves, laxer, not rigid, more-flowered racemes.

Coast Region. Malmesbury Div.: Moorreesberg, 150 m., *Bolus*, 9959!

Plate XIX.

2. L. LEUCOCLADA, Dümmer, comb. nov. *Lebeckia leucoclada*, Schlechter in Engler's Jahrb. XXVII. 143.

South Africa. Coast Region. Clanwilliam Div.: Oliphants River, 150 m., *Schlechter*, 8477! Central Region. Calvinia Div.: On hills, Bitterfontein, 390 m., *Schlechter*, 11049!

A species wrongly assigned to *Lebeckia*, which differs from the preceding in its more robust habit, broader, cuneate, often emarginate leaflets and relatively larger flowers; in general appearance it approaches *L. gracilis*, Benth., var. *brevipetiolata*, Dümmer and Jennings.

3. L. RIGIDA, Bentham, l.c. 597; Harvey, l.c. 50. *Aulacinthus rigidus*, E. Meyer, l.c. 157.

South Africa. Coast Region. Worcester Div.: Near Mordkuil by the Doorn River, Boschesveld Range, *Drège b!*

Drège's specimen at Kew is incomplete, having no flowers and only one legume.

4. L. VIBORGIOIDES, Bentham, l.c. 597; Harvey, l.c.

South Africa. Coast Region. Uitenhage Div.: Hassaquas Kloof, *Zeyher! Zeyher*, 2319.

Without precise locality. *Thom*, 41! 537! *Bowie! Auge* and *Masson*, in Herb. Brit. Mus.!

§ 2. KREBSIA.

5. L. CYTISOIDES, Bentham, l.c. 598 (in part); Harvey, l.c. 50 (in part). *Telina cytisoides* and *T. ericocorpa*, E. Meyer, l.c. 68. *Krebsia stricta*, Eckl. and Zeyh. Enum. Pl. 179.

South Africa. Coast Region. Alexandria Div.: Between Hoffman's Kloof and Drie Fontein, *Drège b!* Bathurst Div.: Between Port Alfred and Kaffir Drift, *Burchel* 3844! Near Barville Park, *Burchell*, 4140!

Albany Div.: Albany, *Bowie!* *Atherstone*, 49! Grahamstown, *MacOwan!* Stockenstroom Div.: Chumie Berg. *Ecklon* and *Zeyher*, 1284! Komgha Div.: Grassy places at the Key River, 320 m. *Drège a!* Somerset East: Bruintjes Hoogte, *Burchell*, 3044!

Eastern Region. Kentani Div.: Hill slopes, 360 m. *Alice Pegler*, 389! Griqualand East: On slopes of Mount Currie, 1950 m., *Tyson*, 1351! Natal: Between Umzimkulu and Umkomanzi River, *Drège a!* Boschberg, 1200 m., *MacOwan*, 896!

Kalahari Region. Orange River Colony, *Cooper*, 1074!

Var. BREVIFOLIA, comb. nov. *L. cytisoides*, Bentham and Harvey (in part). *Telina brevifolia*, E. and Z. ex Drège in Linnaea XIX. (1847), 639. *T. cytisoides*, E. Meyer, l.c. 68 (in part).

South Africa. Coast Region. Uitenhage Div.: Uitenhage, *Zeyher*, 856! On grassy places, Addo, 300–600 m., *Drège c!* *Harvey*, 856! British Kaffraria Div.: *Cooper*, 61! Albany Div.: Mouth of the Kowie River, *MacOwan*, in *Herb. Hance*, 16072! Somerset East, *Scott Elliot*, 602!

Eastern Region. Natal Div.: Boschberg, *Scott Elliot*, 602!

Without locality. *Zeyher*, 2308!

Var. SERICEA, *mihi* var. nova. A typo vexillo postice superne valde hirsuto-sericeo recedit.

Central Region. Prince Albert Div.: Burghersdorp, *Flanagan*, 1543! (*Herb. Albany* and *Zürich*).

Eastern Region. Natal: Grassy hill, Umhlongwe, 150 m., *Wood*, 3011! 448!

A species varying considerably in the length and breadth of the leaves and the nature of the indumentum; Ecklon and Zeyher's specimens (No. 1284) are more erect and like Drège's *Telina eriocarpa*, have a very hirsute calyx, but intermediate forms suggest the correctness of Bentham's interpretation of the species. The latter variety may easily be distinguished from the type by the vexillum, which is hirsutely sericeous posticously on the upper half, the lower half and short claw being glabrescent.

6. L. BIFLORA, Dümmer, comb. nov. *Buchenroedera biflora*, Bolus in Jour. Bot. (1896), 18.

South Africa. Eastern Region. Natal Div.: *Gerrard*, 1086, partly! Zululand Div.: Entumeni, 600 m., *Wood*, 3988!

In the writer's opinion this species has been wrongly referred to *Buchenroedera*, as in its general facies it conforms to the *Krebsia* section of the genus, nor is the calycine character opposed to this view. It exhibits a close relationship to the preceding species, differing however in being more glabrous; leaves less acute or occasionally truncate, with conspicuous midribs and thickened margins. The flowers show but little difference, the standard being slightly sericeous posticously.

7. L. Wyliei, *Wood,* Natal Plants, IV. t. 350; Gard. Chron. (1904), ii. 182.

South Africa. Kalahari Region. Orange River Colony: Mont aux Sources, 2400–2700 m., *Evans,* 753!

Eastern Region. Zululand: Entumeni, 600–900 m., *Wylie, Herb. Wood,* 8962, 9442.

A singularly handsome and striking shrub, 4–5 feet high, easily recognised by the silvery indumentum, which recalls that of certain Podalyrias. The leaves are broadly cuneate, the flowers the largest of the section, of a deep blue, of which the standard is densely fulvously pubescent on the dorsal surface. Specimens of Wylie's collections are apparently not at Kew, but No. 753 of Evans undoubtedly represents a more inland form of this species.

8. L. carnosa, Bentham, l.c. 598; Harvey, l.c. 51. *L. buchenroederoides,* Schlecter, in Jour. Bot. (1897), 279. *Telina striata,* E. Meyer, l.c. 68. *Krebsia carnosa,* Ecklon and Zeyher, Enum. Pl. 180.

South Africa. Coast Region. Fort Beaufort Div.: Winterberg, *Mrs. Barber!* Queenstown Div.: Leysseton Nek, 1200 m., *Galpin,* 1951! Somerset East, *MacOwan,* 930!

Eastern Region. Tembuland Div.: Tsomo River, *Mrs. Barber,* 794! Pondoland Div.: Between Umtata and the St. John's River, *Drège!* Griqualand East: Stony places above Kokstad, 1500 m., *Tyson, Herb. Norm. Aust.-Afr.,* 517! *Tyson,* 1104! ex *Herb. Bolus,* 6161! Natal: Grassy slopes of the Boschberg, 1200 m., *MacOwan,* 228!

Without precise locality. *Bowker! Mrs. F. W. Barber,* 780! *Herb. Bolus,* 187! 311!

Var. condensata, Harvey, l.c. 594.

South Africa. Eastern Region. Transkei Div.: *Bowker, Herb. Dublin.*

The variety is unknown to me, but the description infers that it is distinct; it is reputed to differ in the longer, linear stipules and the terminal subumbellate racemes. *L. buchenroederoides,* Schlechter, is inseparable from this species.

9. L. divaricata, Bentham, l.c. 599; Harvey, l.c. 51. *L. genuflexa,* Bentham, l.c.; Harvey, l.c. *Telina genuflexa,* E. Meyer, l.c. 69. *Krebsia divaricata,* Ecklon and Zeyher, Enum. Pl. 179. *K. genuflexa,* Steud. Nom. ed. II. i. 850. *Aspalathus obtusata,* DC. Prod. II. 143? (not Thunb.). *Leptidium divaricatum,* Presl. Bot. Bemerk. 49.

South Africa. Coast Region. Queenstown Div.: Stony places on mountain-slopes near Shiloh on the Klipplaat River, *Ecklon* and *Zeyher*, 1825! Mountain-sides, Queenstown, 1200–1500 m., *Galpin*, 1947! Cathcart Div.: Windvogelberg and Zwart Kei River, 900–1200 m., *Drège a!*

Central Region. Albert Div.: Burghersdorp, *Cooper*, 782! 571. Somerset Div.: *McArthur*, 34! Colesburg Div.: At Naauw Poort, *Burchell*, 2777! Zuureberg Range, *Burke*, 391! Murraysburg Div.: On the banks of a river near Murraysburg, 1300 m., *Tyson*, 97! Graaff Reinet Div.: *Bowker*, 20!

Mr. N. E. Brown is disposed to agree with me that the two species proposed by Bentham cannot now be maintained, as more recent material tends to show their conspecificity.

10. L. SERICOPHYLLA, Bentham, l.c.; Harvey, l.c.

South Africa. Coast Region. Caledon Div.: Wolf Kloof, near Caledon, *Burke* and *Zeyher! Zeyher*, 399.

11. L. GALPINII, Dümmer, sp. nov. distincta *L. sericophyllae*, Bentham, affinis sed habitu dense ramosiore, indumento carina alisque exceptis valde griseo-strigilloso, ramis brevibus recedit.

Fruticulus dense ramossisimus, ad 15 cm. altus, ubique nisi alis carinaque valde griseo-strigillosus, conferte foliatus; rami ad 7 cm. longi, superne foliati, inferne nudi, subangulati, nigrescentes. *Folia* trifoliolata; petioli foliola aequantes, compressiusculi; foliola saepissime conduplicata, auguste cuneata, acutata, subaequilonga, 3–3·5 mm. longa, juniora utrinque pallide ochraceo-strigillosa, mox cinerascente-strigillosa, coriacea; stipula unica, foliolis similis, saepius paulo major. *Flores* singuli, folio oppositi, vel ramulos laterales brevissimos terminantes aut terminales, bracteolati, violaceo-purpurei (ex *Galpin*); pedicelli 2 mm. longi, bracteola subulata medio instructi. *Calyx* circiter 6 mm. longus, ad medium fissus, extra griseo-pilosus; lobi superiores inferiore paullulo breviores. *Vexillum* perbreviter unguiculatum, in toto 10 mm. altum; lamina fere reniformis, dorso valde griseo-strigillosa, basin versus glabrescens; alae omnino 7·5 mm. longae, glaberrimae, limbo oblique oblongo obtuso basi vix auriculato; unguis limbo brevior; carina alis paulo longior, glabra, limbo oblique late naviculare 5 mm. longo 3 mm. lato obtuso basi obtuse sagittato. *Stylus* fere genuflexus. *Legumen* fere rectum, anguste oblongum, vix turgidum, 15 mm. longum, 2–2·5 mm. latum, undique valde griseo-strigillosum.

South Africa. Eastern Region. Natal: Source of the Tina River, summit of the Drakensberg, 2625 m. *Galpin*, 6600!

Var. PROSTRATA, *mihi* var. nova. A typo habitu prostrata, foliolis paulo majoribus distinguitur.

Natal. Eastern slopes of the Drakensberg, Tsitsa Footpath, 2355 m., *Galpin*, 6601!

12. L. DICHILOIDES, Sonder in Linnaea, XXIII. 1850, 28; Harvey, l.c. Wood, Natal Plants, VI. t. 509.

South Africa. Eastern Region. Natal: Near Durban, *Gueinzius*, 25 and 632. Inanda, *Wood*, 958! *Gerrard*, 1084! *Mrs. K. Saunders!* Mount Moreland, 120 m., and grassy flats, Umhlali, 150 m. *Haygarth* ex *Herb. Wood*, 740!

13. L. HIRSUTA, Schinz in Bull. Herb. Boiss. VII. (1899), 33.

South Africa. Kalahari Region. Transvaal: Houtbosch, *Rehmann*, 6265! Makapansberge, Streydpoort, *Rehmann*, 5532! On the mountains about Houtbosch, 1350–1470 m. *Bolus*, 10947! Modderfontein, 126! 126a!

Distinguished from the preceding by the dwarfer, more hirsute habit, shorter, more acuminate leaflets, and smaller rose-coloured flowers.

14. L. TRANSVAALENSIS, Dümmer, sp. nov. *L. hirsutae,* Schinz, affinis, sed laxe foliata, pilis brevibus arcte adpressis haud patentibus instructa, foliolis longioribus angustioribus, floribus paucioribus recedit.

Herba perennis e basi lignescente ramosa, undique foliorum pagina superiore excepta adpresse breviter strigillosa, caulibus ascendentibus perpaucis fere simplicibus gracillimis teretibus ad 20 cm. altis laxe foliatis pallide brunneis aut citrinis, internodiis ad 3·5 cm. longis. *Folia* trifoliolata; petioli plerumque 5 mm. longi, supra canaliculata; foliola recta vel interdum paullulo falcata, anguste oblanceolata, acutata, 7–13 mm. longa, 1–2 mm. lata, inter se aequalia aut interdum terminalia lateralibus paulo longiora, subtus adpresse breviter strigillosa, medio costata, supra glaberrima costa immersa, subcoriacea, virescentia, margine incrassata; stipulae binae, foliolis similes, sed duplo aut triente breviores et angustiores. *Flores* bini vel interdum usque ad 5 in axillis foliorum superiorum aut oppositifolii umbellatim congesti aut rarissime in racemos lateralos secundos brevissimos dispositi, pedicellis ad 1·5 mm. longis suffulti. *Calyx* 5–6 mm. longus, subquinquefidus, extra stramineo-sericeus, laciniis subulatis. *Vexillum* ad 9 mm. altum; lamina ovata, acutata, e basi rotundata, ungui lato duplo saltem longior, intra glabra, rubida, extra undique sericea; alae breviter unguiculatae, in toto 6–7 mm. longae, laminis rectis anguste oblongis obtusis e basi auriculatis, ad marginem infimum breviter ciliatis; carina alis similis nisi latior et extra undique sericea, frontem versus rubescens. *Ovarium* circiter 5 mm. longum, stylo leviter curvato superne glabro ovario aequialto. *Legumen* inmaturum?, oblongum, rectum, compressiusculum, 7 mm. longum, 2·5 mm. latum, parce sericeum.

South Africa. Kalahari Region. Transvaal: Krügerspost at Lydenburg, *Wilms*, 226a! 226!

The species is easily distinguished from *L. hirsuta*, Schinz, by the inconspicuous indumentum, and fewer and longer leaves. *Wilms's* specimens are labelled *Buchenroedera* sp.

15. L. PAUCIFLORA, Dümmer, sp. nov. *L. transvaalensi*, Dümmer, affinis, sed habitu graciliore rigidioreque, foliolis paullulo brevioribus angustioribus, utrinque adpresse strigillosis, floribus solitariis paucis recedit.

Fruticulus circiter 20 cm. vel altior, fere ubique inconspicue adpresse breviter strigillosus, e basi lignoso ramosus, caulibus paucis parce ramosis ascendentibus aut subfastigiatis gracillimis teretibus pallide citrineis laxe foliatis. *Folia* ascendentia, internodiis aequilonga vel breviora, trifoliolata; petioli teretiusculi, 2–4 mm. longi, pallide citrinei; foliola lineari-lanceolata vel lineari-oblanceolata, acutiuscula vel paulo reflexo-acutata, basin versus sensim angustata, circiter 5–8 mm. longa, 1–2 mm. lata, terminalia lateralibus paulo longiora, subcoriacea, subtus costa prominula, supra costa impressiuscula, utrinque parce adpresse strigillosa, pallide viridescentia; stipulae binae, erectae, oblique lanceolatae, acutae, ad 5 mm. aut longiores. *Flores* solitarii, folio oppositi, flavescentes?, breviter pedicellati, ascendentes vel post anthesim patentes. *Calyx* 5–6 mm. longus, extra valde sericeus, laciniis superioribus subulatis tubo aequilongis, lobo inferiore ceteris paullulo breviore. *Vexillum* breviter unguiculatum, 8–10 mm. altum, limbo ovato apicem versus sensim acuto basi abrupte rotundato, postice ubique sericeo intra glabro; alae anguste oblongae, laminis 4–5 mm. longis obtuse-rotundatis auriculatis ad margines inferiores sparse adpresse hirsutulis, unguibus curvatis scariosis glabris limbo fere aequilongis; carina 5 mm. longa, 2 mm. lata, basi anguste auriculata, extra omnino parce sericea, (sicco) violaceo-purpurea, ungui recto gracili 2–2·5 mm. longo glabro stramineo. *Ovarium* utrinque nisi suturo inferiore sericeum, stylo apicem versus subcurvato glabro ovario fere aequilongo, stigmate oblique subcapitato. *Legumen* leviter turgidum, rectum, 10 mm. longum, parce sericeum, fuscum, styli basi persistente coronatum.

South Africa. Eastern Region. Natal; Drakensberg Range, Coldstream, *Rehmann*, 6904!

16. L. DIGITATA, Harvey, l.c. 52.

South Africa. Western Region. Little Namaqualand: Between rocks near Spektakel, 360 m., *Bolus, Norm. Aust.-Afr.* 430! *Herb. Bolus*, 6551! On hills near Stinkfontein, 270 m., *Schlechter*, 11075!

It is curious that Harvey mentions this species as having been gathered in the Eastern Provinces by Captain Carmichael about 1814, as all specimens obviously agreeing with his description, and observed by the writer, come from the Western Region of Cape Colony in Little Namaqualand.

17. L. BENTHAMIANA, Dümmer, sp. nov. *L. digitatae*, Harvey, affinis, sed foliolis brevius petiolatis brevioribus obtusis, carina late naviculari vexillum aequilonge, leguminibus recedit.

Fruticulus xerophyticus, ad 30 cm. altus, interdum fere aphyllus, ramis lateralibus patentibus saepe distiche dispositis ad 7·5 cm. longis vel rarissime fere abortivis laevibus inconspicue adpresse pubescentibus demum glabris pallide stramineis parce foliatis. *Folia* quinquefoliata, rarissime trifoliolata; petioli 2–4 mm. longi, ubique inconspicue adpresse pubescentes; foliola anguste oblanceolato-cuneata, rotundata aut recurvo-apiculata, superiora 3–6 mm. longa, infima ceteris paulo breviora, subtus parcissime adpresse pubescentia, deinde utrinque glabra, coriacea, viridescentia; stipulae singulae, falcato-lanceolatae, acutae, 1–2 mm. longae. *Racemi* oppositifolii aut axillares, circiter 10 mm. longi, 3–4-flori, rarius uniflori, floribus breviter pedicellatis pallide stramineis, bracteola subulata minutissima suffultis. *Calyx* ad 6 mm. longus, extra sericulus, mox glaber, dentibus superioribus anguste triangularibus longitudinis fere attingentibus 1 mm. longis, lobo antico deflexo subulato 3 mm. longo. *Corolla* glaberrima; vexillum in toto 10 mm. altum, lamina late elliptica 3·5 mm. lata utrinque paullulo angustata tunc e basi subito truncata, aliquando in unquem brevem attenuata; alae conduplicatae, fere rectae; limbi oblongi, 8 mm. longi, obtusi, e basi truncati, vix sagittati, ungui 2 mm. longo; carina in toto 10–11 mm. longa, limbo late naviculare fere 5 mm. lato obtuso basi valde saggitato aut obtuse auriculato. *Stylus* valde prorso curvatus, ovario dimidio brevior. *Legumen* breviter stipitatum, dolabriforme, 10–11 mm. longum, compressum, sericulum, 3–4-spermum. *L. quinata*, Harvey, op. cit. 63 nec Bentham. *Ononis quinata*, Thunb. Prod. 130?

South Africa. Western Region. Little Namaqualand: Near Ookiep, *Morris* ex *Herb. Bolus*, 5622! *Scully*, *Herb. Norm. Aust.-Afr.*, 1127! *Scully*, 150! Steinkopf, *M. Schlechter!*

Harvey erroneously associated this plant with *L. quinata* of Bentham, who founded his description upon E. Meyer's *Lipozygis quinata*, a wholly distinct plant, which is easily distinguished by its less robust habit (an annual occasionally), shorter and more strigillose leaflets, narrower flowers and legumes. I have been unable to ascertain whether *Ononis quinata*, Thunberg, is a synonym of this proposed species.

§ 3. TELINA.

18. L. BRACTEATA, Bentham in Hook. Lond. Jour. Bot. II. 600. Harvey, l.c. 53.

South Africa. Kalahari Region. Transvaal. Mooi River, *Burke* and *Zeyher, Herb. Kew*, 385!

19. L. AZUREA, Bentham, l.c. 600; Harvey, l.c. 53. *Telina heterophylla*, E. Meyer, l.c. 69, excl. syn. *Crotalaria azurea*, Ecklon and Zeyher, l.c. 174.

South Africa. Coast Region. Humansdorp Div.: Between the Kabeljouw and the Gamtoos River, *Drège!* Uitenhage Div.: Near Uitenhage, *Zeyher*, 922! Vanstadens River, 75 m., *Schlechter*, 6072! *Bowie!* Port Elizabeth Div.: Krakakamma and Port Elizabeth, *Ecklon* and *Zeyher*, 1262! Near Port Elizabeth, *Pappe! Burchell*, 4528! In sandy places near Algoa Bay, *MacOwan*, 1127! *Mrs. T. V. Paterson, Herb. Zürich*, 179!

Var. LANCEOLATA, Harvey, l.c. *Ononis villosa*, Thunb. Prod. 129.

Coast Region. Oudtshoorn Div.: On hills at the Moerass River, between Oudtshoorn and Robinson's Pass, 480 m., *Bolus*, 11767!

20. L. MINOR, Dümmer et Jennings. *L. azureae*, Bentham, similis nisi partibus omnibus minor.

Herba perennis, parvula, prostrata aut decumbens, magisminusve parcissime breviter adpresse strigillosa, caulibus brevissimis conferte foliatis. *Folia* trifoliolata, unistipulata; petioli ad 4 mm. longi, incrassati, supra sulcati; foliola anguste oblanceolata aut cuneata, acutata vel rotundata, aequilonga, 3–7 mm. longa, 1–2·5 mm. lata, basi paullulo barbata, vix nervata, coriacea, glaucescentia; stipula reflexa, oblanceolata, foliolis similis, petiolo aequalis vel eo longior. *Flores* oppositifolii, singuli, pedunculati, violaceo—purpurei (fide *Galpin*); pedunculus arcuato-gracilis, ad 2 cm. longus, bracteola unica, subulata, 3 mm. vix excendente. *Calyx* circiter 5 mm. longus, extra parce adpresse strigillosus, mox glaber, lobis aequilongis subulatis tubum aequantibus vel eo longioribus ciliatis. *Vexillum* unguiculatum, toto 10–12 mm. altum, lamina suborbiculari postice superne sericula, ungui glabro fere aequali; alae unguiculatae, in toto 6 mm. longae, limbis curvato-oblongis rotundatis glaberrimis, carina alis similis sed paullulo longior. *Ovarium* ad margines hirsutulum, stylo valde prorso arcuato glabro, stigmate oblique subcapitato. *Legumen* anguste oblongum, rectum, vix turgidum, 10 mm. longum, suturis strigillosis basi calyce persistenti instructum.

South Africa. Eastern Region. Mount Fletcher Div.: Doodman's Krans Mountain, 2700 m. *Galpin*, 6602, *Herb. Kew!*

L. azurea in miniature.

21. L. PROSTRATA, Bentham, l.c. 600; Harvey, l.c. 53. *L. vexillata*, Eckl. and Zeyh. l.c. 176. *Telina prostrata*, E. Meyer, l.c. 69. *Ononis prostrata*, Burm. Prod. 21. *O. heterophylla* and *O. elongata*, Thunb. Prod. 129. *Crotalaria vexillata*, E. Meyer, in Linnaea, VII. (1832), 153.

South Africa. Coast Region. Cape Div.: Cape Town, *Bowie! Alexander*, 37! Lion's Back, *Wolley Dod*, 29! Oude Molen, *Wolley Dod*, 2793! Seapoint side of Lion's Head, *Scott Elliot*, 1059! *Tyson*, 2504! Lion's Head, 150 m., *Drège b!* At the foot of Lion's Head and Signal Hill, *Ecklon*, 424! *Pappe!* 90–300 m., *Herb. Dümmer*, 397! *Dümmer, Pl. Penin. Cap.* 60 F! Green Point, *MacOwan*, 30 m., 1830! 3290! On the slopes of Devil's Peak and Lion's Head, *Ecklon* and *Zeyher*, 1270! *Wilms*, 3147!

Without precise locality. *Forbes! Harvey! Pappe! Lehman! Mund* and *Maire! Bowie! Masson! Brown!* *

Var. GLABRIOR, Bentham, l.c.; Harvey, l.c. 53. *Lotononis excisa*, Steud., Nom. Bot. II. 73. *Telina excisa*, E. Meyer, l.c. 70.

South Africa. Coast Region. Worcester Div.: Dutoit's Kloof Mountains, 600 m. *Drège!*

Without locality. *Bowie!*

Var. HETEROPHYLLA, Harvey, l.c. *L. heterophylla*, Ecklon and Zeyher, Enum. Pl. 177.

Coast Region. Tulbagh Div.: Near Tulbagh, *Pappe! Ecklon* and *Zeyher*, 1273.

Var. MAJOR, Dümmer, var. nova, floribus fere duplo majoribus.

Habitu specie sed robustior; vexillum perbreviter unguiculatum; lamina reniformis, 22 mm. lata, dorso medio linea pilorum instructa.

Coast Region. Malmesbury Div.: Darling, *Bachmann, Herb. Zürich* and *Kew*, 569!

22. L. MACRA, Schlechter in Jour. Bot. (1898), 373; *L. maira*, K. Schumann in Just Jahresb. XXVI. i. 354.

South Africa. Coast Region. Clanwilliam Div.: Clayey slopes near Wupperthal, 1050 m., *Schlechter*.

This plant, according to the author, shews an alliance to *L. varia*, Steud., and *L. macrocarpa*, E. and Z., but may be readily recognised by its habit, linear acute leaflets, and stipules, and by the pilose standard and ovary. According to him it is rare, two plants having only been found by him among *Elytropappus Rhinocerotis*, Less., the Rhenoster Bosch of the Colonists.

* The collections of Bowie, Masson, Niven, and R. Brown are with few exceptions preserved in the British Museum.

23. L. villosa, Steud. ex Bentham in Hook. Lond. Jour. Bot. II. 601; Harvey, l.c. 54; *Telina villosa*, E. Meyer, l.c.; *Lipozygis villosa* Bth. l.c. 609.

South Africa. Coast Region. Malmesbury Div.: Riebeck's Castle below 300 m., *Drège!*

24. L. acuminata, Ecklon and Zeyher, Enum. Pl. 176; Harvey, l.c.

South Africa. Uitenhage Div.: On the fields by the Zwartkops River, *Zeyher*, 868! *Ecklon* and *Zeyher*, 2309! Albany Div.: Albany, *Bowie!* Port Elizabeth Div.: Along the Bakens River near Port Elizabeth, *Burchell*, 4361!

25. L. argentea, Ecklon and Zeyher, Enum. Pl. 176; Harvey, l.c. 54. *Leptis argentea*, Walp. Repert. ii. 837. *Lipozygis argentea*, Meisn. ex Hook. Lond. Journ. Bot. ii (1843), 80.

South Africa. Coast Region. Robertson Div.: Barren hills between Kokmanskloof and the Gauritz River, *Ecklon* and *Zeyher*, 1272.

A small specimen collected by Burchell (Nr. 4463) near Uitenhage may probably belong here, but the material is insufficient to be absolutely conclusive.

26. L. varia, Steud. Nom. Ed. II. ii. 73; Bentham, l.c.; Harvey, l.c. *L. stipularis*, Schlechter in Engler's Bot. Jahrb. XXVII. (1900), 147. *Telina varia*, E. Meyer, l.c. *Polylobium varium*, Presl. Bot. Bemerk. 135.

South Africa. Coast Region. Paarl Div.: Drakenstein Mountains, 600–900 m., *Drège b!* French Hoek, 960 m., *Schlechter*, 9237! Cape Div.: Table Mountain, 300–600 m., *Drège a!* Cape Town, *Alexander!* Stellenbosch Div.: On slopes, Schongezigt, near Stellenbosch, J. X. M. *Herb. Bolus*, 6495! Caledon Div.: Near Palmiet River, *Guthrie, Herb. MacOwan! Grisbrook, Herb. Bolus*, 4743! Swellendam Div.: On the plains near Swellendam and Uitenhage, *Bowie!* Near Breede River, *Bowie!*

Without locality, *Thom*, 724!

Schlechter's specimens are identical with those of *Drège's* upon which the species was founded, hence his name cannot be maintained.

27. L. solitudinis, Dümmer. *L. prostratae* valde affinis sed paene toto glabra, stipulis minutis, foliolis late subobcordatis aut fere rotundatis, calyce breviore, facile distinguenda.

Herba perennis, habitu *L. prostratae*, Benth., similis sed paene ubique glabra et minus diffusa. *Folia* trifoliolata; petioli ad 6 mm. aut saepissime breviores, complanati, supra paullulo sulcati; foliola late subobcordata aut fere rotundata, terminalia sessilia, 6 mm. longa vel breviora, lateralia perbreviter petiolulata, terminalibus duplo minora, vix nervata, subcoriacea, siccantia fere nigrescentia; stipulae binae? late subulatae, 1 mm. haud superantes. *Flores* folio oppositi, singuli, longe pedunculati, flavidi?; bracteolis aperte obsoletis; pedunculus ad 45 mm. altus aut brevior. *Calyx* ad 5 mm. longus, dentibus superioribus (4) late deltoideis 1–1·5 mm. longis, inferiore simili nisi paulo angustiore et longiore. *Vexillum* longe unguiculatum, in toto 12 mm. altum, lamina anguste (transverse) reniformis, ungui rigidiore brevior; alae unguiculatae, lamina ungui fere aequali, late oblonga, obtusa, e basi fere truncata; carina alis similis, nisi paullulo longior latiorque. *Ovarium* 7 mm. longum, rectum, glabrum, stylo arcuato-geniculato brevius. *Legumen* ignotum.

South Africa. Kalahari Region. Transvaal. At Klaste ? on the Vaal River, *Wilms, Herb. Mus. Brit.* 400!

L. solitudinis superficially resembles one-flowered forms of *L. prostrata*, Benth. and *L. varia*, Steud., but the entire glabridity of the plant easily distinguishes it from either; the stipules are also very minute, while the calyx is comparatively short; its isolated inland distribution from a section, which is more or less geographically confined to the coastal regions, has suggested the specific name. Like *L. macrocarpa*, Eckl. and Zeyh., the plant dries a dark brown or black.

28. L. MACROCARPA, Ecklon and Zeyher, Enum. Pl. 176, Bentham, l.c. 602; Harvey, l.c. 55.

South Africa. Western Region. Little Namaqualand: Modderfontein (Karies), 100 m. *Schlechter*, 7969!

Coast Region. Clanwilliam Div.: Brak Fontein, *Zeyher*, 403! Piquetberg Div.: Piquenier's Kloof, 255 m. *Schlechter*, 4925. Malmesbury Div.: Vicinity of Hopefield, *Bachmann, Herb. Schinz*, 1970!

29. L. MARLOTHII, Engler, in Bot. Jahrbuch, X. (1888), 26.

South Africa. Kalahari Region. Griqualand West: In sandy places near Kimberley, 1200 m. *Marloth, Herb. Engler. Marloth*, Exs. aust.-afr. 765! Christiana, *Nelson*, 197! *Scott Elliot*, 1243!

30. L. BARBERAE, Dümmer, sp. nov. *L. Marlothii*, Engler, valde affinis sed partibus omnibus majoribus, racemis 2–5-floris recedit.

Herba perennis, multiramosa, diffusa, omnino parcissime adpresse strigillosa aut demum glabrescens, caulibus decumbentibus gracillimis ad 12 cm. longis vel longioribus internodiis variantibus. *Folia* trifoliolata; petioli patentes, 20–25 mm. rarissime ad 70 mm. longi, supra profunde sulcati; foliola elliptica aut lineare-lanceolata vel oblanceolata, fere utrinque angustata, interdum apiculata, lateralia 5–20 mm. longa, 2–4 mm. lata, rarissime 40 mm. longa, terminalia paulo vel interdum duplo longiora, utrinque paene glabrescentia, subtus costa inferne prominente superne evanida, supra laevia, herbacea, pallide viridescentia; stipulae singulae aut binae? minutae, ovato-acutae vel subulatae. *Racemi* axillares, paene secundi, 2–5-flori, pedunculo gracillimo paullulo arcuato 20–40 mm. longo glabro. *Flores* patentes, perbreviter pedicellati, undique glabri, bracteola lineari minutissima. *Calyx* 2·5–3 mm. longus, dentibus subulatis tubo paene aequilongis. *Vexillum* 5–6 mm. altum, membranaceum, limbo orbiculare ungui paulo longiore; alae anguste oblongae, 6 mm. longae, basi subsagittatae; carinae limbus late navicularis, obtusus, basi hastatus. *Ovarium* 3 mm. longum, suturis fronteque hirsutulum, stylo arcuato glabro fere longius, stigmate oblique subcapitato. *Legumen* anguste oblongum, subfalcatum, 7–8 mm. longum, 8-spermum, glabrescens.

South Africa. Kalahari Region. Orange River Colony: Without precise locality, *Mrs. Barber!*

Differs from *L. Marlothii* in its more luxuriant habit and 2–5-flowered, almost secund racemes, and though bearing a striking resemblance to forms of *Listia heterophylla*, its legumes are essentially those of a *Lotononis*.

31. L. MAGNISTIPULATA, Dümmer, ab *L. Marlothii*, fere omnino patentim hirsutula, foliolis brevius petiolatis majoribus ciliatis floribusque recedit.

Herba perennis, diffusa aut prostrata, distiche ramosa, ramulis gracilibus ad 7·5 cm. longis teretibus patentim hirsutis aut adpresse strigillosis. *Folia* bistipulata, trifoliolata; petioli ad 5 mm. longi; foliola obovata vel elliptica, breviter acuta sed saepe utrinque angustata, inter se aequalia, ad 10 mm. longa, 5 mm. lata, subcoriacea, subtus obscure costata, adpresse pilosula, supra costa impressa, demum glabra, ciliata; stipulae foliolis simulantes, saepissime aequimagnae, acutae aut cuspidatae. *Inflorescentia* terminalis vel axillaris, 2-flora, rarissime uniflora; flores umbellato-dispositi, flavidi, pedunculo ebracteato gracili ad 25 mm. longo adpresse strigilloso; bracteola subulata, calyce brevior. *Calyx* 6 mm. longus, infra medium fissus, parcissime adpresse pilosus aut demum glaber, laciniis anguste triangularibus subaequilongis. *Vexillum* 8 mm. altum, membranaceum, limbo orbiculare posteriore ad costam marginemque apicem versus adpresse hirsutulum, ungui parvulo glabro; alae breviter unguiculatae, late oblongae, fronte rotundatae, basi superne subauriculatae, glabrae, limbis 5 mm. longis unguibus tertio longioribus; carina alis simulans nisi latior. *Ovarium* rectum, valde adpresse hirsutum, 5 mm. longum, stylo curvato duplo brevicre, stigmate oblique subcapitato.

South Africa. Eastern Region. Natal: Fakus Territory, *Sutherland, Herb. Kew!*

§ 4. POLYLOBIUM.

32. L. UMBELLATA, Bentham, l.c. 602; Harvey, l.c. 55. *Lipozygis umbellata*, E. Meyer, l.c. 76. *Polylobium filiforme* and *P. truncatum*,

Eckl. and Zeyh. Enum. Pl. 181. *P. umbellatum*, Bth., in Ann. Wien, Mus. II. (1838), 142. *Ononis strigosa*, Thunb. Prod. 130, *O. anthylloides*, DC. Prod. II. 168.

South Africa. Coast Region. Paarl Div.: Klein Drakenstein Mountains, 300 m. *Drège a !* Cape Div.: On the slopes of the Devil's Peak and Table Mountain, *Ecklon* and *Zeyher*, 1292! *Rehmann*, 850! 851! *Alexander*, 42! *Ecklon*, 568! *Wilms*, 3146! *Wolley Dod*, 27! 1355! *Dümmer, Herb.* 154! *Dümmer, Pl. Penin. Cap.* 15 C! At the foot of Table Mountain near Wynberg, 90 m., *Bolus*, 4702! Slopes of Lion's Head, *MacOwan* and *Bolus*, 68! Swellendam Div.: Zondereinde River near Linde, *Ecklon* and *Zeyher*, 1291. Swellendam, *Bowie !* George Div.: Between Malgaten and the Great Brak River, *Burchell*, 6146!

Without locality. *Harvey*, 102! *Lehman ! Niven*, 132! *Masson !*

33. L. PROCUMBENS, Bolus in Jour. Bot. (1896), 18.

South Africa. Kalahari Region. Orange River Colony: Bester's Vlei, Harrismith, 1620 m., *Bolus*, 8139! *Sankey*, 44!

34. L. DEBILIS, Bentham, l.c. 604; Harvey, l.c. 55. *Polylobium debile*, Ecklon and Zeyher, Enum. Pl. 181. *Leptidium debile*, Presl. Bot. Bemerk. 49.

South Africa. Coast Region. Swellendam Div.: Carroid hills near Hassaquas kloof, *Ecklon* and *Zeyher*, 1290. Zondereinde River, Zeyher, 2316. Port Elizabeth Div.: Sand dunes near Port Elizabeth, 15 m., *Bolus*, 2666!

35. L. BACHMANNIANA, Dümmer, sp. nov. *L. debili*, Bentham, affinis nisi mox toto glabra et rigidior, foliolis longioribus obovato-lanceolatis, stipulis geminis, calycibus inconspicue sericeis.

Planta fere toto glabra, e basi lignescente perenni, caulibus paucis decumbentibus vel ascendentibus gracilibus teretiusculis parce foliatis ad 18 cm. longis. *Folia* ascendentia, trifoliolata, omnino glabra; petioli foliolis aequilongi vel duplo longiores, supra sulcata; foliola obovato-lanceolata, cuneata, rotundata, mucronata, intermedia 9–14 mm. longa, 2·5–3·3 mm. lata, lateralia breviora, subcoriacea, mox glabra, supra costa impressa, subtus costa prominula nervis lateralibus obsoletis; stipulae binae, arrectae, subulatae, circiter 4 mm. altae. *Capitulum* oppositifolium, 5–8-florum, floribus ochraceis; pedunculus ad 3 cm. altus, pedicellis cum calycibus parce sericeis 6–7 mm. longis. *Calycis* dentes deltoidei, subulati, vix 1·5 mm. excedentes. *Vexillum* brevissime unguiculatum; lamina reniformi, circiter 1 cm. lata; alae graciliter unguiculatae, toto 8–9 mm. longae, limbis oblonguisculis rotundatis basi fere attenuatis; carina alis similis sed lamina late naviculari rotundata basi truncata. *Ovarium* dorso hirtellum, stylo valde arcuato glabro.

South Africa. Eastern Region. Pondoland. *Bachmann, Herb. Zürich* and *Kew*, 578!

Distinguished from *L. debilis*, Bth., by its less branched glabrous habit, obovate-lanceolate leaflets and totally glabrous corollas.

36. L. PALLENS, Bentham, l.c. 605. Harvey, l.c. 56. *Polylobium pallens*, Ecklon and Zeyher, Enum. Pl. 182.

South Africa. Coast Region. Clanwilliam Div.: Mountain-sides near Brak Fontein, *Ecklon* and *Zeyher*, 1294. This species is not included in the collections examined by me.

37. L. ANGOLENSIS, Welwitsch ex Baker in Oliv. Fl. Trop. Afr. ii. 6. *Argyrolobium deflexiflorum*, Baker in Kew Bulletin (1897), 253.

Tropical West Africa. Angola. Huilla and Pungo Andongo, 720–1650 m., *Welwitsch*, 1895 and 1896! Mossamedes, *Newton*, 97! North-West Rhodesia; on mica schist near Pemba, 1050 m., *Rogers*, 8558! Makoli, *Rogers*, 8285! Between Goudkopje and Katzele, 1250 m. *Baum, Herb. Zurich*, 199!

Tropical East Africa. Tanganyika Plateau, Fort Hill, 1050–1200 m., *Whyte !*

38. L. BAINESII, Baker, l.c.

Tropical South-West Africa; lat. 23°. *Chapman* and *Baines !* German South-West Africa, Hereroland, *Dinter*, 473!

This species is very closely allied to the preceding, and more material may hereafter suggest its approximation to it.

39. L. INVOLUCRATA, Bentham, l.c. 602 (in part).

A diffuse or decumbent plant, densely covered all over, excepting the upper surfaces of the leaflets and the corolla, with long spreading foxy hairs; shoots up to 35 cm. ft. long, angular, distichously branched (very rarely simple), the lateral branchlets rarely exceeding 15 cm. in length, densely leafy. *Leaves* trifoliolate; petiole up to 10 mm. long, flattened; leaflets linear to lanceolate, subacute, the lateral slightly falcate and up to 14 mm. long; terminal invariably straight and slightly larger, subcoriaceous; stipules geminate, spreading, leaf-like but more acute. *Umbels* indistinctly pedunculate, subglobose, 5–10-flowered, subtended by a whorl of conspicuous and leafy ovate-lanceolate, often cuspidate bracts; flowers shortly pedicellate. *Calyx* about 10 mm. long, densely covered externally with long foxy hairs and cleft below the middle; segments subulate. Standard clawed, 12 mm. high; limb broadly triangular, obtuse, almost truncate at the base, glabrous except for a longitudinal line of hairs posticously; wings 12 mm. long, entirely glabrous; limbs conduplicate, narrowly oblong, obtuse to rotundate, auriculate at the base; keel similar to the wings, but the limb slightly broader. *Ovary* hirsute in front, the hairs extending to about the middle of the style; style twice as long as the ovary, arcuate, glabrous above and terminated by an oblique subcapitate stigma. Harvey, l.c. 56 (in part). *Lipozygis involucrata*, E. Meyer, l.c. *Ononis involucrata*, Berg, Pl. Cap. 213.

South Africa. Coast Region. Malmesbury Div.: Grassy places, Groene Kloof, 100 m., *Bolus!* Stellenbosch Div.: Stellenbosch, *Sanderson!* At the foot of the Hottentots' Holland Mountains, *Bunbury!* Sir Lowry's Pass, *Schlechter, Herb. Zürich*, 23! Paarl Div.: Paarl Mountain, 300–600 m., *Drège! Klapmuts, Schlechter, Herb. Zürich*, 383! Tulbagh Div.: Stony slopes near Steendal Post, Tulbagh, 300 m., *MacOwan, Herb. Norm. Aust.-Afr.* 561! On the slopes of the Winterhoek Mountain, *Lamb* ex *Herb. Dümmer*, 1484! Swellendam Div.: On sandy parts of the Houw Hoek and Swellendam Mountains, *Bowie!*

Without locality. *Lehmann! Scholl! Thom! Forbes! Forbes*, 148! *Masson! Niven*, 143!

40. L. TENUIFOLIA, Dümmer, comb. nov.

Habit of the preceding species, but less robust and the indumentum much less conspicuous; stem often unbranched. *Leaflets*—15 mm. long, narrowly cuneate or oblanceolate, rotundate and often mucronulate, occasionally acutate; stipules subulate to lanceolate. Umbels pedunculate, 3–7-flowered, bracts much less conspicuous than in *L. involucrata*, Benth.; peduncles 30 mm. long; flowers often nodding, pedicels 2–3 mm. long. Calyx persistent, about 9 mm. long, sparingly appressedly pilosulate externally, cleft to the middle, segments narrowly deltoid, the lower narrower and slightly longer. Standard about 10 mm. high, limb rounded at the base, sparingly appressedly hirsute posticously above the middle; limbs of the wings not conduplicate, truncate at the base. *Legume* turgescent, oblong, 12 mm. long, ochreous, sparingly hirsute on the sutures and in front.

L. involucrata, Bentham, l.c. (in part); Harvey, l.c. (in part). *Polylobium tenuifolium*, and *P. angustifolium ?* Ecklon and Zeyher, Enum. Pl. 182.

South Africa. Coast Region. Malmesbury Div.: Sandy places near Darling, *Schlechter, Herb. Zürich*, 5334! Vredenberg, *Bachmann, Herb. Zürich*, 2075! Cape Div.: Cape Town, *Alexander*, 38! *Forbes! Wilms*, 3148! Devil's Peak, *Burchell*, 8498! Vicinity of Cape Town, Newlands and Paradise, *Burchell*, 489! Simonsbay, *Wright!* Wynberg Hill, *Wolley Dod*, 28! Path beyond Miller's Point, *Wolley Dod*, 2879! Roadside near Noah's Ark Battery, *Wolley Dod*, 1253! Muizenberg, *Scott Elliot*, 1086! Table Mountain, 180–240 m., *Dümmer, Herb.* 154!

830! Stellenbosch Div.: Hottentot's Holland Mountains, *Ecklon* and *Zeyher*, 1295!

Without locality. *Burke! Harvey*, 775! *Forbes! Scholl! Sieber*, 164! *Masson! Menzies! Bergius!*

41. L. PEDUNCULARIS, Bentham, l.c. 602; Harvey, l.c. Var. *Meyeri*, Harvey, l.c. *Lipozygis peduncularis*, E. Meyer, l.c. 79. *Polylobium pedunculare*, Bentham, in Ann. Wien. Mus. ii. (1838), 142. *Ononis umbellata*, Linn. Mant. ii. 266.

South Africa. Coast Region. Malmesbury Div.: Laauwskloof near Groenekloof, below 300 m., *Drège b!* Paarl Div.: Near Paarl, below 300 m., *Drège a! Pappe*, 28!

Var. SECUNDA, Harvey, l.c. *Ononis secunda*, Thunb. Prod. 130.

Coast Region. Caledon Div.: Genadendal, *Alexander*, 40!

The variety is doubtfully distinct from the type.

42. L. ANGUSTIFOLIA, Steud., Nom. Bot. ii. 73; Bentham, l.c. 603; Harvey, l.c. 57. *L. secunda*, Bth., l.c. excl. syn. *Telina angustifolia*, E. Meyer, loc. cit. 70. *Polylobium fastigiatum* and *P. Mundianum*, Eckl. and Zeyher, l.c. 183.

South Africa. Coast Region. Paarl Div.: Klapmuts, *Rehmann, Herb. Zürich!* Cape Div.: False Bay, *Alexander*, 43! On hills near Cape Town, *Zeyher!* Sandy flats, *Rehmann*, 2102! Retreat, 15 m., *Dümmer, Herb.** 1212! Table Mountain, 90 m., *MacOwan* and *Bolus*, 56! By Tokay Convict Prison, *Wolley Dod*, 2256! 723! Zeekoe Vley, *Ecklon* and *Zeyher*, 183. Koeberg, *Pappe!* Caledon Div.: On the Zwartberg, *Bowie!* Swellendam Div.: Swellendam, *Mund.*

Without locality. *Bowie! Harvey*, 801!

43. L. NEWTONI, Dümmer, species nova, distincta, facie *L. angustifoliae*, Steud., similis sed foliolis hirtellioribus, capitulis brevissime pedunculatis ramulos laterales breves terminantibus, floribus sessilibus minoribus hirtellis, vexillo parvulo facillime distinguenda.

Planta annua, omnino hirtella, cauli simplice erecta 15 cm. alta foliosa citrinea. *Folia* trifoliolata, ascendentia; petioli supra sulcati, 5–7 mm. longi; foliola anguste lanceolata, acutata, terminalia 7–10 mm. longa, ceteris paulo longiora, subcoriacea, enervata, margine paullulo incrassata; stipulae binae, arrectae, foliolis similes, nisi minores angustioresque, ad 6 mm. longae. *Capitula* depresse hemisphaerica, 5–10-flora,

* This collection, comprising approximately 2100 species, exclusively South African, is in the Herbarium of the Royal Botanical Gardens, Edinburgh.

ad 10–13 mm. diametro, foliolis ea saepe excedentibus; pedunculi laterales foliosi, ad 8 mm. longi; bracteae inverse late triangulares 2–2·5 mm. longae. *Flores* subsessiles, hirtelli, flavidi. *Calyx* 5–6 mm. longus, segmento inferiore acuminato fissis superioribus duplo longiore. *Vexillum* parvulum, cucullatum, calycen vix excedens, lamina fere reniformi perbreviter cuspidata postice hirtella, ungui scarioso profunde sulcato: alae 4–5 mm. longae, laminis unguibus subaequilongis vix 1 mm. latis frontem versus attenuatis basi obsolete auriculatis ad marginem inferiorem hirsutulis; carina alis vix duplo longior, lamina frontem versus ampliata, basi attenuata, extra omnino hirtella. *Ovarium* hirsutulum, stylo arcuato glabro tertio aut quadruplo eo longiore.

Tropical Africa. Angola. Mossamedes, Moulino, *Newton, Herb. Zürich* and *Kew*, 95!

A peculiarly distinct plant with the general facies of *L. angustifolia*, Steud., though easily recognised by the more hairy slender habit, shortly pedunculate depressedly hemispheric flower-heads, subsessile smaller hairy flowers, and inconspicuous vexillum, which scarcely extrudes from the calyx.

44. L. TRICHOPODA, Bentham, l.c. 603; Harvey, l.c. 57. *L. trifolioides*, Schlechter ex Zahlb. in Ann. Nat. Hofm. Wien, xx. (1905), 16. *Crotalaria trichopoda*, and var. *brachypoda*, E. Meyer, l.c. 154. *Polylobium intermedium* and *P. typicum*, Eckl. and Zeyh., l.c. 180, 181. *P. trichopodum*, Presl. Bot. Bemerk. 123. *Ononis glabra*, Thunb. Prod. 130.

South Africa. Coast Region. Uitenhage Div.: Between Coega and the Sunday Rivers, below 300 mm., *Drège a! Ecklon* and *Zeyher*, 1289! Van Staden's River below 300 m., *Drège b!* Uitenhage, *Zeyher*, 401! Addo, *Ecklon* and *Zeyher*, 1288. Algoa Bay, *Alexander*, 39! Oudtshoorn Div.; At the Brook and near the Cango Caves, Oudtshoorn, 330 m., *Bolus*, 11768! Oudtshoorn, *Miss L. Britten*, 56! Albany Div.: Redhouse, *Mrs. T. V. Paterson*, 401! Port Elizabeth Div., New Brighton, Port Elizabeth, *Mrs. E. Southey*, 5869! (*Herb. Kew!*).

This species varies somewhat in the degree of pubescence and the relative length of the peduncles, Schlechter's description of *L. trifolioides* does not in any way differ from certain specimens, which I consider forms of this species.

45. L. MONOPHYLLA, Harvey, Thesaurus, Cap. i. 39, t. 63; Harvey, l.c. 58.

South Africa. Coast Region. Uitenhage Div.: Stony places on the Vanstadensberg, *Zeyher, Herb. Kew!*

§ 5. LIPOZYGIS.

46. L. PENTAPHYLLA, Bentham, in Hook. Lond. Jour. Bot. II. 605. Harvey, l.c. 59. *Lipozygis pentaphylla,* E. Meyer, l.c. 79.

South Africa. Western Region. Little Namaqualand. Little Karakuis, *Drège !* *Scully, Herb. Norm. Aust.-Afr.* 1126 ! *Scully, Herb. Brit. Mus.* 135 ! On hills, Eenkokerboom, 280 m., *Schlechter,* 11067 ! Without locality. *Masson* and *Niven, Herb. Brit. Mus.* 30 !

47. L. ROSEA, Dümmer, sp. nov., a *L. pentaphylla,* Benth., caulibus longioribus fere glabrescentibus laxe foliatis, foliolis longioribus anguste cuneatis, inflorescentiis paulo majoribus, floribus majoribus pallide roseis recedit.

Planta annua?; radix fusiformis, caulibus decumbentibus gracilibus paene simplicibus circiter 20 cm. longis teretiusculis laevibus hirtellis aut mox glabrescentibus pallide ochraceis. *Folia* rosulata vel ad caules laterales parce disposita, quinquefoliolata, rarissime trifoliolata; petioli filiformes, 10–40 mm. longi, parce hirtelli; foliola anguste cuneata oblanceolatave, apice rotundata aut paene truncata, inaequalia, terminalia 8–20 mm. longa, lateralia 5–18 mm. longa, utrinque sparse adpresse pilosula, subtus costa prominula; stipula foliacea, lanceolata, ad 10 mm. alta. *Capitula* oppositifolia, sessilia, foliis breviora, fere globosa, densa, circiter 20 mm. diametro; flores brevissime pedicellati, pallide rosei, bracteola lineari-lanceolata, subulata, calycem fere aequante. *Calyx* profunde fissus, 12 mm. longus, extra valde hirtellus, laciniis superioribus subulatis 8 mm. longis, inferiore paullulo breviore. *Corolla* parce sericea. Vexillum ad 10 mm. altum, limbo anguste ovato aut cordato rotundato basin versus in unguem brevem attenuato; alae anguste oblongae, in toto 10–12 mm. longae, obtusae, basi auriculatae; ungues 2–3 mm. longi; carina paulo curvata, 7 mm. longa, medio 1–1·5 mm. lata, obtusiuscula, basi auriculata aut subsagittata, unguibus gracilibus limbo brevioribus. *Ovarium* dimidio ellipticum, 4–5 mm. longum, valde utrinque hirsutulum; stylus filiformis, ovario duplo longior, inferne rectus, parce hirsutulus, superne mox curvatus, glaber, stigmate subcapitato. *Legumen* haud visum.

South Africa. Coast Region. Clanwilliam Div.; Clanwilliam, *Mader,* 207 !

48. L. POLYCEPHALA, Bentham, l.c. 605; Harvey, l.c. 59. *Lipozygis polycephala,* E. Meyer, l.c. *Polylobium polycephalum,* D. Dietr., Syn. Pl. IV. 962.

South Africa. Western Region. Little Namaqualand, between Pedros Kloof and Lily Fontein, 900–1200 m., *Drège, Herb. Kew !*

49. L. ANTHYLLOIDES, Harvey, loc. cit. 59.

South Africa. Western Region. Namaqualand, *Wyley*, *Herb. Kew !*

50. L. BOLUSII, Dümmer, sp. nov. *L. anthylloidi*, Harvey, valde affinis sed foliis longe pedunculatis, stipulis lanceolatis aut anguste cuneatis, foliolis longioribus herbaceis haud coriaceis, capitulis terminalibus (rarius lateralibus) distinguenda.

Herba annua? viscidula, juventute paene undique patentim valde hirsuta; radix anguste fusiformis, vix fibrosa; caules laterales, decumbentes, graciles, 15 cm. vix excendentes, teretes, laeves, inferne paene glabrescentes, parce laxeque foliati, brunnei. *Folia* conferte-rosulata vel ad caules laterales alternatim disposita et minora, quinquefoliolata vel interdum trifoliolata; petioli ascendentes, filiformes, 7–70 mm. longi, juniores valde patentim albo?—hirsuti; foliola anguste cuneata, rotundata vel fere truncata, mucronata aut brevissime cuspidata, terminalia 10–30 mm. longa, 4–9 mm. lata, infima saepe 5–15 mm. longa, supra fere glabra, subtus parce pilosa, costa basi prominente, apicem versus evanida, nervis lateralibus obsoletis, herbacea, viridescentia, laxe ciliata; stipula lanceolata vel anguste cuneata, mucronata, ad 12 mm. longa, ciliata. *Capitula* terminalia, rarissime lateralia, solitaria, breviter pedunculata, globosa aut ovoideo-globosa, ad 20 mm. diametro; flores paene sessiles, albidi, bracteolis foliatis lanceolatis subulatis valde hirsutis flores maturos haud excedentibus. *Calyx* 8 mm. longus, extra hirsutus, profunde fissus, laciniis subaequalibus subulatis. *Vexillum* circiter 10 mm. altum, limbo vix reflexo obovato vel elliptico acutato basi paullulo auriculato fere glabro ungui gracili longiore; alae angustissime oblongæ, fere rectae, in toto 8–9 mm. longae, glaberrimae, unguibus gracillimis; carina alis similis, tamen latior et obtusior, curvata, basi graciliter auriculata. *Ovarium* oblique ovatum, 3 mm. longum, fronte valde hirsutum; stylus filiformis, fere duplo longior, glaber, inferne subito deflexus, deinde rectus, summo apice paene geniculatus.

South Africa. Coast Region. Piquetberg Div.: In sandy places near Piquetberg, 105 m., *Bolus*, 8431!

Var. MINOR, var. nova, a typo capitulis minoribus recedit.

Coast Region. Malmesbury Div.: In the vicinity of Hopefield, *Bachmann*, *Herb. Zürich* and *Kew*, 2228!

This variety differs from the type in the relatively smaller flower-heads, which are 1–1·3 cm. in diameter.

Var. SESSILIS, var nova, typo similis nisi capitulis sessilibus.

Coast Region. Tulbagh Div.: Between Tulbagh Kloof and Piqueniers Kloof, 120 m., *Herb. Bolus* and *Kew*, 8969!

The sessility of the globose flower-heads, which are 1·5–1·7 cm. in diameter, distinguish this variety from the species.

51. L. Wilmsii, Dümmer, sp. nov. distincta *L. erianthae*, Benth., affinis sed habitu humiliore, foliolis aequilongis brevissimis angustissimisque, stipulis geminis, floribus minoribus facillime distinguenda.

Suffruticulus tunc 9 cm. vix excedens, ramossisimus, specie viscidus, ramulis ascendentibus magisminusve simplicibus teretibus strigillosis brunneis dense foliatis. *Folia* subimbricata, trifoliolata; petioli persistentes, teretes, usque ad 5 mm. longi; foliola recta, rarissime subfalcata, aequilongia, linearia aut lineari-lanceolata, acuta, petiolis aequilonga, subtus parcissime strigillosa, supra demum glabra, incrassata, enervata; stipulae binae, foliacea, oblique lineares vel lineari-lanceolatae, foliola aequates vel interdum superantes. *Inflorescentia* sessilis, terminalis, hemisphaerica, 4–8-flora vel interdum uniflora; flores perbreviter pedicellati, flavidi, bracteola minutissima. *Calyx* 6–7 mm. longus, extra pilosulus, nervatus, laciniis inter se aequilongis tubum aequantibus, superioribus anguste triangularibus, inferiore angustiore. *Vexillum* 8 mm. altum limbo ovato cuspidato, cuspi cucullato incurvoque, basi subhastato vel fere auriculato extus ad costam et apicem versus sericeo aut omnino postice-sericeo; unguis anguste oblongus, 2 mm. longus, glaber; alae 5 mm. longae, fronte obtusiusculae, basi valde auriculatae, ad margines parcissime sericeae, ungui angusto glabro limbo breviore; carina dimidio obovata, fronte fere rotundata, sagittata, 6·5–7 mm. longa, extra valde brunneo-sericea; ungues glabri. *Ovarium* anguste dimidio ellipticum, 3·5 mm. longum, frontem versus hirsutulum; stylus ovario duplo longior, prorso arcuatus, basin versus hirsutulus, stigmate oblique subcapitato.

South Africa. Kalahari Region. Transvaal Div.: Between Middleberg and the Crocodile River, *Wilms, Herb. Kew*, 277!

52. L. Sutherlandii, Dümmer, sp. nov. distincta *L. erianthae*, Dümmer, maxime affinis sed habitu magis ramoso, foliolis obovato-cuneatis crassioribus utrinque pubescentibus, calycis dentibus brevioribus, distinguenda.

Suffruticosus, laxe magisminusve distiche ramosus, inferne nudus, ramis florentibus ascendentibus circiter 7–10 cm. longis puberulis foliatis. *Folia* trifoliolata, internodiis longiora, ubique pubescentia; petioli graciles, 3–5 mm. longi; foliola obovato-cuneata, rotundata, mucronata aut brevissime cuspidata, lateralia 5–10 mm. longa, 2·5–4 mm. lata, terminalia ceteris paulo majora vel rarius duplo longiora, dorso costa prominula, nervis lateralibus obsoletis, supra canaliculata, subcoriacea, viridescentia; stipula unica, falcato-lanceolata, acuta, 4 mm. rarius excedens. *Flores* terminales vel raro axillares, solitarii sed saepissime in umbellas sessiles ramulos laterales breves terminantes, sicco ochracei; pedicelli 1–3 mm. longi, bracteola subulata, triente longiores. *Calyx* extra parce adpresse pubescens, 4 mm. longus, lobis anguste deltoideis tubo duplo brevioribus, inferiore ceteris paullulo longiore. *Vexillum* 8–10 mm. altum, lamina reflexa elliptica utrinque subangustata obtusa quam ungui duplo longiore postice undique parce sericea intra ut ungui glabra; alarum limbi fere oblongi, rotundati, basi perspicue obtuse sagittati, cum unguibus 8–9 mm. longi, extra sericuli; carinae limbus late navicularis, 6–7 mm. longus, ad frontem rotundatus, obtuse auriculatus, extra ubique sericulus; ungues graciles, limbo paulo breviores, glabri. *Ovarium* lineare, suturo dorso apicem versus hirsutulum; stylus curvatus, superne glaberrimus, stigmate subcapitato.

South Africa. Eastern Region. Natal. Without precise locality, *Sutherland, Herb. Kew !*

53. L. ERIANTHA, Bentham, l.c. 605; Harvey, l.c. 59.

South Africa. Kalahari Region. Basutoland, *Cooper*, 2269! Transvaal: Magaliesberg, *Zeyher*, 363! 412! Houtbosch, *Rehmann*, 6267! On the mountains about Houtbosch, 1310 m., *Bolus*, 10948! Near Lydenburg, *Wilms*, 279! Pretoria, *Wilms*, 279a (partly)! 278! Near Robinsons, *Burtt Davy*, 2992! Plakfontein at the Beacon, 1800 m., *Burtt Davy*, 2975!

Eastern Region. Natal: Near Van Reenen's Pass, 1800 m., *Wood*, 4525! Oliver's Hoek Pass, *Wood*, 1300 m., 3602! Pietermaritzberg, 900 m., *Sutherland! Wilms*, 1925! Drakensberg, 1500–1800 m., *Wood*, 6631! Grassy hill near Newcastle, 1200 m., *Wood*, 5866!

Var. OBOVATA, Scott Elliot in Jour. of Bot. (1891), 69.

South Africa. Eastern Region. Tembuland, Umtata, Bazeia, 750 m., *Baur*, 560! 623! Natal: Near Maritzburg, *Wood*, 3163! Imquela Mountain, *Scott Elliot*, 1637! Griqualand East Div.: Mount Currie, 1650 m., *Tyson*, 1415!

54. L. PULCHRA, Dümmer, sp. nov. variabilis, L. *erianthae*, Benth., affinis, sed foliolis supra fere glabris, corollis glaberrimis recedit.

Herba perennis, e basi lignoso ramosa, caulibus erectis vel ascendentibus perpaucis aut confertis ad 28 cm. altis plerumque simplicibus angulatis mox teretibus hirtellis ochraceis saepe valde foliatis. *Folia* patentia vel subimbricata, trifoliolata; petioli usque ad 5 mm. longi; foliola subfalcato-lanceolata, elliptica aut obovato-oblonga, rotundata vel acutata, ad 18 mm. longa, 3–6 mm. lata, terminalia lateralibus paulo longiora, supra fere glabra, subtus parce hirtella, laete viridescentia, longe ciliata, subcoriacea; stipula unica, arrecta, foliolis similis iis saepissime breviora, rarius aequilonga, extus hirtella. *Flores* terminales, corymbosim congesti, (rarius ramulos laterales brevissimos terminantes), citrinei, roseo-suffusi; corymbae hemisphaericae, pluriflorae, (raro pauciflorae), ad 3·5 cm. diametro, laterales terminalibus minores floribus paucioribus; pedicelli ad 10 mm. longi, pilosuli, bracteola lineari duplo aut tertio breviore medio instructi. *Calyx* 7–8 mm. longus, extra hirtellus, dentibus superioribus anguste deltoideis, lacinia inferiore subulata dentibus duplo longiore. *Corolla* glaberrima; vexillum unguiculatum, 10–12 mm. longum, limbo late ovato acutato aut obtuso vel breviter cuspidato, basi rotundato vel subhastato unguem linearem scariosum sulcatum aequante; alae falcatae, oblongae, apicem versus angustatae, rotundatae, basi longe sagittatae, 6–10 mm. longae, limbo ungui gracili breviore aut superante; carina alis similis, late navicularis, medio vix 3 mm. lata, obtusiuscula, basi auriculata, unguibus gracilibus 3–4 mm. longis. *Ovarium* frontem versus hirsutulum, stylo prorso curvato brevius, stigmate simplice.

South Africa. Kalahari Region. Transvaal: At the town, Lydenburg, *Wilms*, 280! 279a partly! *Atherstone!*

Eastern Region. Griqualand East: On the slopes of Mount Malowe, 1200 m., *Tyson*, 2721! *Herb. Aust.-Afr.*, 1253! Between Ibisi River and Clydesdale, *Tyson*, 1414. Natal: *Mrs. K. Saunders!* Inanda, *Wood*, 454! In grassy places, Botha's Hill, *Tyson*, 3109! Stony and grassy slopes near Friendenau Farm, 600 m., *Rudatis*, 259! Rocky hill, Liddesdale, *Wood*, 4253.

In common with its ally, *L. corymbosa*, Benth., this species exhibits considerable variation in its habit, indumentum, and size of flowers, but intermediate forms suggest the advisability of regarding the specimens quoted as forms of one variable species, which may be distinguished from either of its congeners by the entire glabridity of its corollas.

55. L. CORYMBOSA, Bentham, l.c. 606; Harvey, l.c. 60. Wood, Nat. Plants, VII. 12, t. 235. *Lipozygis corymbosa*, E. Meyer, l.c. *Polylobium corymbosum*, Bentham, in Ann. Wien Mus. ii. (1838), 142.

South Africa. Eastern Region. Tembuland Div.: Umtata River, below 300 m., *Drège!* Near Cala, *Bolus*, 8844! Natal: *Gerrard*, 1063! Port Natal, *Krauss*, 436! *Sutherland!* Inanda, *Wood!* Lidgetton, 1200 m., *Wood*, 9753! *Wood*, 182! *Mrs. K. Saunders! Rehmann*, 8419! 7835! Krantz Kloof, 500 m., *Schlechter*, 3184! Sevenfontein Hill, *Wylie* ex *Herb. Wood*, 5218! Between Greytown and Newcastle, *Wilms*, 1926!

Kalahari Region. Transvaal: Eastern slopes of the Saddleback Mountain, 1350–1500 m. Barberton, *Galpin*, 1164! *Bolus*, 7710! Swazieland: Havelock Concession, 1200 m., *Galpin*, 1012! *Miss M. M. Stewart!*

A highly variable species, difficult of limitation, of which extreme forms appear to merge into *L. eriantha*, Benth., on the one hand, and *L. pulchra*, Dümmer, on the other. According to Medley-Wood (l.c.), *L. corymbosa*, Bth., is known to the natives as *um-Hloboluku* or *um-Hlambaluku*, the roots being used as a tonic by them. The differences of *L. eriantha* and *L. corymbosa* as given in the key are based on extreme forms.

56. L. LANCEOLATA, Bentham, l.c. 606; Harvey, l.c. 60. *Aspalathus lanceolata*, E. Meyer, l.c. 37.

South Africa. Central Region. Aliwal North Div.: Between Kraai River and the Wittebergen, 350–1500 m., *Drège!* Kalahari Region. Transvaal: Klip River Berg Range near Johannesburg, *Rand, Brit. Mus.*, 1111! Eastern Region. Zululand, *Gerrard*, 1065!

57. L. FOLIOSA, Bolus, in Jour. Linn. Soc. (Bot.) XXIV. (1887), 173.

South Africa. Kalahari Region. Orange River Colony: *Cooper*, 862! Harrismith, *Sankey*, 46! Bronkerspruit, *Rehmann*, 6565! 6609! 6590! Transvaal, Near Pretoria, 1260 m., *McLea, Herb. Bolus*, 5620! *Nelson*, 268! Johannesburg, *Rogers*, 2548! *Scott Elliot*, 1348! Ommanney, *Rand*, 953! Greylingstad, *Vandeleur!* Pilgrim's Rest, *Greenstock!* Near Johannesburg, *Miss R. Leendertz*, 1705! Swazieland: em-Babaan, 1380 m., *Burtt-Davey*, 2864! Near Bruig Spruit, *Schlechter, Herb. Zürich*, 3755!

Eastern Region. Natal: Near Klip River, 1150–1500 m. *Sutherland!* Between Pietermaritzberg and Greytown, *Wilms*, 1928! Oliver's Hoek Pass, *Wood*, 3542! Near Mooi River, 1500 m., *Wood*, 768! Zululand: *Gerrard*, 1068!

Cooper's specimens (No. 862) have perfectly glabrous corollas, while those of *Wood* (No. 768) are sericeous.

58. L. GRANDIS, Dümmer et Jennings, sp. nov. *L. foliosae*, Bolus, affinis, sed habitu robustiore, foliis longius petiolatis majoribus exstipulatis, capitulis fere nudis et floribus majoribus facillime distinguitur.

Herba undique nisi corolla laxe et longe albo-villosa. *Caules* florentes (annui e radice perenni?) erecti, stricti, simplices, ad 0·5 m. alti, 4-goni, irregulariter sulcati, dense foliosi. *Folia* trifoliolata (exstipulata?), petioli ad 1 cm. longi, supra sulcati; foliola elliptico-oblonga vel lanceolata, utrinque angustata aut apiculata, terminalia ad 5 cm. longa, 8–11 mm. lata, lateralia paulo breviora, medio costata, sicco subnigra, chartacea, longe laxeque ciliata. *Capitulum* terminale, solitarium, hemisphaericum, subnudum, compacte 25–30-florum, circiter 4 cm. diametro. *Flores* pedicellati, flavidi (fide *Wylie*); pedicelli filiformes, 0·4–1 cm. longi; bracteola lineari-subulata, ad 4 mm. longa. *Calyx* 7 mm. longus, 10–12 nervatus, extra parce pilosus, supra medio fissus, lobis subulatis inter se subaequalibus. *Vexillum* unguiculatum, spatulatum, in toto 10–12 mm. longum, lamina 8 mm. longa, 2·5 mm. lata, acuta, basi leviter truncata, dorso parce sericea, mox glaberima; alae vix curvatae, in toto 10 mm. longae, limbo 3 mm. lato obtuso sagittato extra parcissime pubescente; carina alis similis sed paulo longior et angustior. *Ovarium* complanatum, falcato-oblongum, 7 mm. longum, stylum valde curvatum aequans, glaberrimum, fuscum.

South Africa. Natal. At the Umzinyati River, 60–120 m. *Wylie, Herb. Wood* and *Kew* 11525 !

A highly decorative and distinct species easily recognised by the characters cited; like its congener *L. foliosa*, Bol., it shows the peculiarity of turning black on drying, a peculiarity manifested by only one more of this section, viz., *L. lanceolata*, Benth.

§ 6. LEOBORDEA.

59. L. CARINALIS, Harvey, in Harv. and Sonder, Fl. Cap. II. 60.

South Africa. Western Region. Little Namaqualand, *Wyley, Herb. Harvey, Dublin.*

60. L. STEINGROEVERIANA, Dümmer, comb. nov. *L. clandestina*, Bth., var. *Steingroeveriana*, Schinz, in Abh. Bot. Ver. Brandenburg, XXX. (1888), 157.

South Africa. Kalahari Region. Lower Orange River, *Steingroever, Herb. Schinz* and *Kew*, 109 !

Differs from the following species in the more caespitose habit, larger flowers and calyces, which latter are subinflated and prominently nervate at maturity.

61. L. CLANDESTINA, Bentham, l.c. 607; Harvey, l.c. 61. *Capnitis clandestina*, E. Meyer, l.c. 81. *Leobordea clandestina*, Steud., Nom. ed. II. ii. 23.

Western Region. Little Namaqualand. Between Holgat River and the Orange River, 300–450 m., *Drège !*

62. L. LEOBORDEA, Bentham, l.c. 607; Harvey, l.c. 61. *L. porrecta*, Bentham, l.c., Harvey, l.c. 60. *L. abyssinica*, Kotschy in Sitzb. Acad. Math.-Nat. li. ii. (1865), 263. L. *dichotoma*, Boissier, Fl. Orient. ii. 30. *L. Leobordea*, Délile in Laborde Voy. Arab. Pétr. 86 (1833). *L. platycarpus*, Viv. Pl. Aegypt. Dec. IV. 14. *L. persica* and *L. sphaerocarpa*, Boiss. Fl. Orient. ii. 30. *Leobordea persica*, Jaub and Spach in Ann. Sci. Nat. Ser. II. XIX. (1843), 235. *L. sphaerosperma*, Jaub and Spach, l.c. 235.

L. abyssinica, Hochst. ex A. Rich. Tent. Fl. Abyss. i. 161. *L. lotoidea,* Délile in Laborde Voy. Arab. Pétr. 86. *L. porrecta,* Steud. Nom. ed. II. ii. 23. *Capnitis porrecta,* E. Meyer, l.c. 81. *Leptis prolifera* and *L. debilis,* Ecklon and Zeyher, l.c. 175.

Africa. South Africa. Coast Region. Uitenhage Div.: Zwartkops River, *Ecklon* and *Zeyher,* 1264. Albany Div.: Between Grahamstown and Bothasberg, *Ecklon* and *Zeyher,* 1265. Central Region. Springbokkeel and Bitterfontein, *Zeyher,* 409! Prince Albert Div.: Zwartbulletje, 900 m., *Drège!* Rhodesia, Bulawayo, *Rand, Herb. Brit. Mus.* 309! Great Namaqualand, Gubub, *Dinter, Herb. Zürich,* 1147! Wilhelmstal, 1400 m., *Dinter,* 346! Inachab, *Dinter,* 1160! Rehoboth, *Fleck, Herb. Zürich,* 462?

British Central Africa. Ruwenzori, *Scott Elliot,* 6820! ABYSSINIA. *Schimper!* Ungëa, *Schimper,* 492! On dry hills near Arna, *Schimper,* 1493! Mountains near Pagero, 1050 m., *Schimper,* 2293! NUBIA. Sea-coast, 900–1200 m., *Bent!* EGYPT. Cairo, *Schubert! Sickenberg! Schweinfurth!* Kordofan, *Pfund,* 396! Desert between Keneh and Kosser, *Schweinfurth,* 764! ALGERIA. Biskra, *Balansa,* 932!

Asia. Arabia. Petraea, *MacDonald! Ehrenberg!* Jeddah, *Nohrab,* 197! 116! 127! Desert near Dschedda, *Schimper,* 768! *Fischer,* 64! Red Sea between 10° and 12° N. lat. *Lord!* Wadi Musa, *Boissier! Aucher-Eloy,* 1041! At the foot of Mt. Sinai, *Schimper,* 414! Wadi Barak, *Hart!* Wadi Gemah, *Lord!* Wadi Farran, *Lord!* Wadi Sewook, *Lord!* Southern Syria, Wadi Zewerah, *Lowne!* Asia Minor, Gediz, *Fischer,* 64. Persia (according to Boissier), BALUCHISTAN. *Stocks,* 698! Between plains of Scinda and Rohill Pass, 150 m., *Stocks,* 698! NORTH-WEST INDIA. Punjaub, near Peshawar, *Stewart,* 422 P!

Turkey in Europe, Central and Northern Midia, *Burton!*

A peculiarly variable and perplexing plant, and perhaps here somewhat misinterpreted, but I have failed to recognise differences sufficiently stable to warrant the resuscitation of any other names. Certain specimens approach *L. clandestina* in having short, stiff and spreading pubescence, but the majority have a more sericeous indumentum; Bové's specimens from the Desert of Sinai labelled *Leobordea lotoidea,* Délile (No. 129) represent a species of Astragalus.

§ 7 LEPTIS.

63. L. QUINATA, Bentham, l.c. 608 (not Harvey). *L. quinata,* var. *minor,* Harvey, l.c. 63. *Lipozygis quinata,* E. Meyer, l.c. 77. *Polylobium quinatum,* Presl. Bot. Bemerk. 123.

South Africa. Western Region. Little Namaqualand: Modderfontein

Berg, 1200–1500 m., *Drège !* Near Ookiep, 900 m., *Bolus, Herb. Norm. Aust.-Afr.* 1129 ! *Bolus,* 9490 !

64. L. DELICATULA, Bolus, in Pl. Nov. Then. I. (1906), 187, t. 41.

South Africa. Western Region. Little Namaqualand: On hills, Brackdam, 540 m., *Schlechter,* 11106 ! On hills, Waterklipp, 690 m., *Schlechter,* 11167 !

Differing from the preceding species in the more diffuse, less woody habit, longer more glabrous leaflets, and slightly longer flowers and legumes.

65. L. LUPINIFOLIA, Bentham, l.c. 607. *Leobordea lupinifolia,* Boissier ex Jaub and Spach in Ann. Sci. Nat. Ser. II. XIX. (1843), 237. Boiss. Voy. Esp. t. 52. *Cytisus pentaphylla,* Salzman ex Walp. Repert. I. 623. *Leobardia villosa* and var. *intermedia,* Pomel. Fl. Atl. I. 163 (1874).

North Africa. Algeria: Djebel Santo, Oran, *Bourgeau,* 126 ! Oran, *Cosson ! Balansa,* 377 ! At the foot of Santa Cruz, Oran, *Munby ! Boissier* and *Reuter !* Lalla Marina, *Warming !* Ghar Rubban, *Munby !* Djébel Santo, *Durando !* and *Debeaux, Herb. Zürich !*

Europe. Mediterranean Region. S. Spain: Malaga, *Boissier,* 61 ! 865 ! *Salzman !* Dry hills, *Joad !* Near Malaga and Casarobonela, *Huter,* 681 ! Andalusia, Ronda, *Reverchon, Herb. Zurich,* 191 !

66. L. LONGIFLORA, Bolus, in Journ. Linn. Soc. XXV. (1889), 159.

South Africa. Western Region. Little Namaqualand: *Dowdle* ex *Herb. Bolus,* 6568 ! (Herb. Kew !) ; *Scully* ex *Herb. Norm. Aust.-Afr.* 1128 ! On hills near Goechas, 900 m., *Schlechter,* 11377 ! *Scully, Herb. Brit. Mus.* and *Edinburgh,* 236 !

A singularly distinct species with the habit of *L. quinata,* Benth., but with large flowers sometimes exceeding 2·5 cm. in length, the standard and wings being relatively short.

67. L. BURCHELLII, Bentham l.c. 612 ; Harvey, l.c. 61.

South Africa. Kalahari Region. Bechuanaland : Between sources of the Kuruman River and Kosi Fontein, *Burchell,* 2539 ! Between Takun and the ruins of Latakun, *Burchell,* 2271 !

68. L. CRUMANINA, Burchell ex Bentham, l.c. 612 ; Harvey, l.c. 62.

South Africa. Kalahari Region. Orange River Colony. Caledon River, *Burke* and *Zeyher,* 405 ! *Burke !* Basutoland, near sources of the Kuruman River at Little Klibbobikhonni, *Burchell,* 2445 ! 2472 !

These specimens, and all those quoted for the preceding species, are in the Kew Herbarium.

69. L. MACULATA, Dümmer, sp. nov. *L. crumaninae*, Burchell, affinis sed habitu minus diffusa, foliolis acutatioribus, floribus semper solitariis paullulo majoribus dignoscitur.

Suffruticosus parvulus, adpresse prostratus, argenteo-fulvido-sericeus, ramis lateralibus arcuatis ad 7 cm. longis foliatis. *Folia* trifoliolata; petioli ad 2 cm. longi, teretes; foliola anguste elliptica vel oblanceolata, acuta, 7 mm. longa, 2·5 mm. lata, inter se fere aequilonga, dorso costata, subcoriacea; stipulae unicae aut binae? minutae, mox deciduae. *Flores* solitarii, axillares aut oppositifolii, subsessiles; bractea subulata, calycis tubum aequans. *Calyx* fere quinquefidus, 7 mm. longus, extra dense hirsuto-sericeus, fissis subulatis. *Vexillum* breviter unguiculatum, 5 mm. altum, lamina late triangulari, postice medio pilifera; alae unguiculatae, 5–6 mm. longae, glabrae, limbis anguste oblongis apicem versus attenuatis; carina calyce brevior, glabra, acutata, basi auriculata; ungues 1·5–2 mm. longi. *Stylus* gracilis, glaber, ovario duplo longior. *Legumen* oblique ovato-orbiculare, compressum, calycem haud excedens, sericulum, 6–8-spermum, seminibus ochraceo-maculatis, funiculis filiformibus albidis.

South Africa. Kalahari Region. Griqualand: Griqua Town, *Burchell, Herb. Kew*, 1957!

A species exhibiting affinities to *L. crumanina*, Burchell, but differentiated by the smaller, less diffuse habit, more acute leaflets, and invariably solitary, slightly larger flowers. Superficially it resembles the only specimen of *L. mollis*, Benth., which the writer has seen, but the acute carina, which never exceeds the calyx in length, and the included legume, serves to distinguish it immediately from that species.

70. L. LAXA, Ecklon and Zeyher, Enum. Pl. 177.; Harvey, l.c. 63. *L. diversifolia*, Bentham, l.c. 611. *Crotalaria diversifolia*, and var. *unifoliata*, E. Meyer, l.c. ii. 27.

South Africa. Coast Region. Albany Div.: Stony and grassy places, Grahamstown, 600 m. *MacOwan*, 911! Queenstown Div.: Near Shiloh, 1000 m., *Drège c!* Queenstown, *Cooper*, 1787! On the Klipplaat River, 1050 m., *Drège b!* Hanglip Mountain, 1500 m., *Galpin*, 1781! British Kaffraria: *Cooper*, 166! 327! *Mrs. Bowker!* Central Region. Graaff Reinet Div.: On the Sneeuwbergen, near Graaff Reinet, 1350 m. *Bolus*, 609! Colesberg Div.: Colesberg, *Shaw!* Albert Div.: *Cooper*, 1397! Kalahari Region. Orange River Colony: Thaba Unchu and Caledon River, *Burke! Zeyher*, 393! 401! 402! *Cooper*, 2184! Transvaal Div.: Pretoria hills, *Miss R. Leendertz*, 259! Between Standerton and Pretoria, *Wilms*, 270! Eastern Region. Transkei Div.: Bashee River, *Drège a!* Natal Div.: Banks of the Tugela River, near Hoffenthal, *Wood*, 3540! Grassy hills, near Colenso, 900 m., *Wood! Schlechter, Herb. Zürich*, 6880!

Var. MULTIFLORA, mihi, var. nova, a typo nisi floribus subumbellatim 2–5-dispositis vix differt.

South Africa. Kalahari Region. Transvaal: Plains near Barberton, 870 m., *Galpin*, 1078a! and 1078b! Hills near Standerton, *Schlechter, Herb. Zürich*, 3458! Irene, near Pretoria, *Conrath*, 135! Orange River Colony, *Cooper*, 2184! Eastern Region. Natal: Among grass, near Colenso, *Wood!* Umtata, 1020 m., *Schlechter, Herb. Zürich*, 6325!

71. L. WOODII, Bolus, in Journ. Bot. (1896), 18. *L. montana* and *L. Schlechteri*, Schinz, in Bull. Herb. Boiss. VII. (1899), pp. 30, 32.

South Africa. Coast Region. Alexander Div.: Zuurebergen, 1440 m., *Schlechter, Herb. Zürich*, 6589! Albany Div.: In grassy and stony places near Grahamstown, 600 m., *MacOwan*, 911! Queenstown Div.: Hanglip Mountain, 1500 m., *Galpin*, 1781! Kalahari Region. Harrismith, 1500 m., *Wood*, 4788! Eastern Region. Natal: Amahwagua, 1800–2100 m., *Wood*, 4603 *Gerrard*, 1731! Fakus Territory, *Sutherland!* Central Region. Transvaal: Standerton, *Rehmann, Herb. Zürich*, 6794!

This plant exhibits the closest affinity to the preceding species, and may hereafter prove to be a geographical form of the Ecklon and Zeyher plant. It differs materially in the longer, broader, and more acute leaflets. Schinz's *L. Schlechteri* (*Schlechter* No. 6589) can only be regarded as a very southern form of this species.

72. L. HUMILIOR, Dümmer, sp. nov. *L. macrosepalae*, Conrath, persimilis habitu humiliore, foliolis stipulis floribusque minoribus differt.

Herba perennis, undique nisi corolla argyreo-tomentosa, e basi lignescente ramosa, caulibus ascendentibus saepissime simplicibus sinuatis perpaucis ad 5 cm. longis. *Folia* trifoliolata aut interdum unifoliolata; petioli teretiusculi, 3–6 mm. longi; foliola inaequalia, obovata, oblanceolata vel elliptica, apice rotundata aut utrinque attenuata, raro mucronulata, 5–15 mm. longa, 3–5 mm. lata, lateralia breviora, subtus costa valde prominula, nervis lateralibus fere obsoletis, supra costa impressiuscula, coriacea; stipula lanceolata, acuta, 2–5 mm. longa. *Flores* solitarii, folio oppositi, ochracei; pedicelli brevissimi. *Calyx* profunde fissus, 8–9 mm. longus, extra valde sericeus, laciniis inter se subaequalibus acuminatis. *Vexillum* cum ungui 9 mm. altum, lamina late obovata aut late triangularis, utrinque glaberrima nisi postice medio longitudinaliter linea pilorum obtecta; alae graciliter unguiculatae, 6 mm. longae, 3 mm. latae, utrinque rotundatae, glaberrimae; carina alis paulo excedens, limbo oblique naviculari, basi fere truncato glabro. *Stylus* glaber, arcuatus, stigmate oblique subcapitato. *Legumen* rectum, compressiusculum, frontem versus paulo angustatum, 15 mm. longum, 4 mm. latum, valde sericeum, 12-spermum.

South Africa. Kalahari Region. Transvaal: At the town, Lydenburg, *Wilms*, 274! Eastern Region. Natal Div.: Without precise locality, *Gerrard*, 1065!

L. macrosepala in miniature; Wilms's specimens are identified as *Crotalaria* sp., but the absence of the rostrum and the compressed pods are opposed to this identification.

73. L. MACROSEPALA, Conrath, in Kew Bull. (1908), 223.

South Africa. Kalahari Region. Transvaal: Stony places, Modderfontein, *Conrath, Herb. Kew*, 133!

Very similar in habit to the preceding but with the leaves always trifoliolate and twice or three times as large, the flowers and legumes correspondingly as large.

74. LOTONONIS DESERTORUM, Dümmer, sp. nov. *L. Dinteri*, Schinz, affinis sed patentim hirsuta, foliolis brevioribus obovato-cuneatis, floribus minoribus, corolla calyce inclusa.

Herba perennis aut *annua*? diffuse-prostrata, ubique patentim stramineo-hirsuta, caulibus gracilibus subangulatis stramineis ad 10 cm. longis conferte foliatis. *Folia* trifoliolata; petioli complanati, ad 5 mm. longi; foliola terminalia elliptica vel obovato-cuneata, subacuta, ad 1 cm. longa, 0·5 cm. lata, lateralia paulo minora et oblique elliptica aut obovato-cuneata, subcoriacea, subtus basin versus costa prominente; stipula solitaria, subulata vel lanceolata, acuta, 2·5–3 mm. vix excedens. *Flores* subsessiles, oppositifolii, solitarii vel bini, lutei (teste *Dinter*). *Calyx* extra patentim hirsutus, 7 mm. longus, profunde fissus, membranaceus, fissis binis supremis acuminatis caeteris majoribus. *Corolla* glabra; vexillum 4–5 mm. altum, breviter unguiculatum, lamina oblongiuscula, 1·5–2 mm. lata, paulo cucullata venis parallelis ornata; alae graciliter unguiculatae, 4–4·5 mm. longae, laminis oblanceolatis 0·5 latis in ungues aequilongos attenuatis; carina alis similis sed curvatior. *Ovarium* valde hirsutum, stylo brevissimo arcuato glabro, stigmate subcapitato.

German South-West Africa. Gr. Barmen, 1200 m., *Dinter, Herb. Zürich* and *Kew*, 518!

A species more with the facies of one of the Leobordea group, but the large abaxial calyx-tooth suggests its approximation to this section; it exhibits an affinity to *L. Dinteri*, Schinz, but is differentiated by the spreading indumentum, shorter obovate-cuneate leaflets, and smaller flowers of which the corolla is included within the calyx.

75. L. UNIFLORA, Kensit, in Trans. Roy. Soc. S. Africa, I. (1909), 147.

South Africa. Kalahari Region. Transvaal: Rustenberg, 1350 m., *Miss*

Olive Nation, 315, *Herb. Bolus*; Maxalaquena River, 1275 m., *Schlechter*, 4280; Transvaal, *Kirk*, 109! Eastern Region Natal: *Gerrard* 1771!

Allied to L. LAXA, Eckl. and Zeyher, but with bistipulate leaves, linear lanceolate almost pungent leaflets, and long peduncled flowers, the peduncle almost at right angles to the axis and often geniculate. Gerrard's specimen from Natal is more slender in all its parts, but otherwise is inseparable. The species extends into Portuguese East Africa, where at Ressano Garcia it has been found by Dr. R. Schlechter (No. 11906).

76. L. DINTERI, Schinz in Vierteljahrsschr. Nat. Ges. Zürich, lii. (1907), 423. *L. clandestina*, Baker, in Oliv. Fl. Trop. Afric. II. 6 (not of Bentham).

Tropical West Africa. Benguella, Mossamedes, in the sands near the sea-shore, *Welwitsch*, 1903! lat. 23°, *Chapman* and *Baines!*

German South-West Africa Hereroland. Otavi, Dinter, 664! Damaraland, *Een, Herb. Mus. Brit.*

Shinz's type specimen in no way differs from those cited by Baker, except in being more luxuriant, and is perfectly distinct from *L. clandestina*, Benth., to which the latter author referred his specimens.

Var. AMBOENSIS, Schinz, l.c.

German South-West Africa. Amboland: Uukuanyama, *Rantanen*, 549, 28. 111.

The variety, which I have not seen, is reputed to differ in its more silvery-grey aspect and shorter leaflets.

77. L. MOLLIS, Bentham, l.c. 609; Harvey, l.c. 64. *Leptis mollis*, Bth., in Ann. Wien Mus. II. (1838), 142. *Lipozygis mollis*, E. Meyer. l.c. 79. *L. villosa*, Benth., l.c. *Leptidium molle*, Presl. Bot. Bemerk, 49. *Polylobium molle*, D. Dietr. Syn. Pl. IV. 962.

South Africa. Western Region. Little Namaqualand: Lily Fontein, Ezel's Kop, 1200–1500 m., *Drège, Herb. Kew!*

A species represented by a small specimen in the Kew Herbarium, which has apparently never been rediscovered since the time of Drège.

78. L. ADPRESSA, N. E. Brown, in Kew Bull. (1906), 18.

South Africa. Eastern Region. Natal: Stony hill near Charlestown, 1500–1800 m., *Wood*, 5712! *Wood*, 6317, *Herb. Natal* and *Edinburgh!*

In many respects not unlike *L. laxa*, Ecklon and Zeyher, but with the indumentum less shiny and more hirsute-sericeous, shorter and broader leaflets, slightly larger flowers with a distinct obtuse carina.

79. L. SERICOFLORA, Dümmer, sp. nov. *L. adpressae*, N. E. Brown,

similis sed foliolis utrinque sericeis, vix hirsuto-sericeis, floribus saepius binis, vexillo angustiore distat.

Planta suffruticosa, prostrata, ramosissima, ubique corollis exceptis, primo subsericea, mox fere strigosa, caulibus teretiusculis ad 12 cm. longis. *Folia* trifoliolata, conferta; petioli ad 4 mm. longi, supra valde sulcati, stipulam unicam subulatam saepe aequantes; foliola anguste cuneata vel oblanceolata, acutata aut mucronulata, inter se fere aequilonga, ad 7 mm. longa, 2 mm. lata, dorso medio costata, subcoriacea. *Flores* solitarii vel interdum gemmati ternative, oppositifolii, breviter pedicellati, roseo-diffusi (in sicco). *Calyx* 6 mm. longus, dentibus superioribus deltoideis 1 mm. vix excedentibus, segmento inferiore subulato ceteris tertio longiore. *Vexillum* spatulatum cum ungui 9 mm. altum, lamina acutata, postice valde sericea, ungui fere longiore; alae breviter unguiculatae, leviter falcato-oblongae, 8·5 mm. longae, apice obtusae, basi obtuse auriculatae, glaberrimae; carina alis similis, nisi latior longiorque, unguibus longioribus, limbo frontem versus et ad marginem inferiorem sericulo. *Ovarium* stylo glabro subaequilongum. *Legumen* rectum, oblongum, compressiusculum, 8 mm. longum, sericulum, 6-spermum.

South Africa. Kalahari Region. Transvaal: Hogge Veld, Standerton, *Rehmann, Herb. Kew* and *Zürich*, 6802!

80. L. MAROCCANA, Ball, in Jour. Bot. XI. (1873), 302; Linn. Soc. Bot., XVI. 394, pl. XV.

North Africa. Morocco: in the Urika valley, 960–1200 m., *Ball!* In stony and sandy places on the Greater Atlas, Ait Mesan, 1200–2000 m., *Ball!* Near Amsmiz, 900–1100 m., *Ball!* Between Taperemont and Ourika, and near Tassgit, *Maw!* Ourika, 900 m., *Hooker!* Siggrat and Ghiliz, *Cosson!*

81. L. GENISTOIDES, Bentham, l.c. 607; Boissier, l.c. 31. *Leobordea genistoides*, Fenzl, Illust. Pl. Taur. in Russ. Rev. 901, t. 4. *L. cytisoides*, Bal. ex Boiss. Fl. Orient, ii. 31. *L. argyrolobioides*, Jaub and Spach, in Ann. Sci. Nat. Ser. II. XIX. (1843), 237. *L. lotoides*, Fenzl, Pugill. Pl. Nov. Syr. 6. *L. sericea*, Ledeb. Fl. Ross. i. 512.

Orient. Dry hills near Elmalu, *Bourgeau*, 95! on hills at Egirdir, *Heldreich!* Taurus Mountains, *Kotschy*, 159! Lydia, about Smyrna, *Balansa*, 184! *Boissier!* Anata, *Wiedeman*. Gulahek, *Balansa!* Phrygia above Ouchak, 940 m., *Balansa*, 1209! Phrygia, Akscheher, in stony places at Yasian, 1000 m., *Bornmüller*, 4260!

82. L. BRACHYLOBA, Benth., l.c. 608; Harvey, l.c. 63. *Lipozygis brachyloba*, E. Meyer, l.c. 78. *Leptidium brachylobum*, Presl. l.c. 49. *Leptis brachyloba*, Bth., in Ann. Wien Mus. II. (1838), 142. *Polylobium brachylobum*, D. Dietr. Syn. Pl. IV. 962.

South Africa. Coast Region. Clanwilliam Div. : Blaauw Berg, 300 m., *Schlechter*, 8462. Piquetberg Div. : On slopes of mountains near Piquetberg, *Bolus*, 7519. Central Region. Ceres Div : Near Yuk River, *Burchell*, 1273 ! Western Region. Little Namaqualand. Between Koper Berg and Kook Fontein, Drège ! ; Riet Kloof, near Bowesdorp, *Schlechter*, 11189 ! or 11183 ! In sandy places near Abbevlakte, 210 m., *Bolus*, 6523 ! ; between Spektakel and Komaggas, 360 m., *Bolus !* ; *Bolus, Herb. Norm. Aust.-Afr.* 444 ! Great Namaqualand, Eisib, *Schinz, Herb. Zürich !*

83. L. FALCATA, Bentham, l.c. 608 ; Harvey, l.c. 64. *L. decipiens.* Schlechter, in Pl. Nov. Then. I. (1906), 183, t. 40. *Lipozygis falcata*, E. Meyer, l.c. 78. *Leptidium falcatum*, Presl. Bot. Bemerk. 49. *Polylobium falcatum*, D. Dietr. Syn. Pl. IV. 962. *Leptis falcata*, Benth., in Ann. Wien Mus. ii. (1838), 142.

South Africa. Western Region. Little Namaqualand : Orange River, near Verleptpram, 150 m., *Drège a !* In a valley of the mountains near Oograbies Poort, 120 m., *Bolus*, 6522 ! *Bolus, Herb. Norm. Aust.-Afr.* 443 ! Namaqualand, *Wyley !* Coast Region. Van Rhynsdorp Div. : Wind Hoek, 90 m. *Schlechter*, 8075 ! Zout River, 130 m., *Schlechter*, 8132, partly ! Clanwilliam Div. : On hills, Brackdam, 540 m., *Schlechter*, 11113 !

Without locality. *Zeyher*, 390 !

Schlechter's specimens of *L. decipiens* do not materially differ from *Drège's* specimen, upon which Bentham founded his species, except in the straighter pods, which character in its entirety cannot be regarded as of sufficient moment to warrant the retention of the name. Wyley's and Zeyher's specimens are peculiar in being nearly a foot high and very fastigiate, but the smaller flowers, their paucity, and the narrow subfalcate pods are sufficient to illustrate the justice of Harvey's view as to their conspecificity. The species extends northward into Great Namaqualand, where Schinz and Dinter have collected it.

84. L. LEPTOLOBA, Bolus, in Engler's Bot. Jahrbuch, XXIV. 457.

South Africa. Coast Region. Van Rhynsdorp Div. : Zout River, 130 m., *Schlechter*, 8131 ! 8143 ! 8130 ! 8132, partly !

An annual like the preceding species, but with slightly shorter obovate-cuneate leaflets, and deeply cleft calyces, twice as long, broader and shorter legumes.

85. L. MAXIMILIANI, Schlechter, in Pl. Nov. Then. I. (1906), 187, t. 41.

South Africa. Coast Region. Clanwilliam Div. : On hills, Achtertuin, 240 m., *Schlechter*, 10851 ! Central Region. Ceres Div. : Near Yuk River, *Burchell*, 1275 !

More robust in all its parts than *L. leptoloba*, Bolus, the leaflets often subacute, and when young, strigillose, the flowers blue and longer pedicellate, the calyces and legumes hirtellous.

86. L. PUMILA, Ecklon and Zeyher, Enum. Pl. 178; Benth. l.c. 609, and var. *micrantha*, Harvey, l.c. 65. *L. micrantha*, Eckl. and Zeyh. l.c. *Lipozygis erubescens* v. *microphylla* and *macrophylla*, E. Mey. l.c. 76 and 77. *Polylobium erubescens*, D. Dietr. Syn. Pl. iv. 962. *Leptis erubescens*, Bth., in Ann. Mus. Wien, ii. (1838), 142. *Leptidium erubescens*, Presl. loc. cit. 49.

South Africa. Coast Region. Riversdale Div.: Gauritz River, *Ecklon* and *Zeyher*, 1283. Uitenhage Div.: Grass ridge, *Ecklon* and *Zeyher*, 1280. Central Region. Willowmore Div.: Zwanepoels Poort, 600 m., *Drège b!* Somerset Div.: Near Little Fish and Great Fish Rivers, 600–900 m., *Drège a!* Somerset, *Mrs. Bowker!* Graaff Reinet Div.: On hills near Graff Reinet, 840 m., *MacOwan*, 599!

87. L. RARA, Dümmer, sp. nov. *L. pumilae*, Eckl. et Zeyh., peraffinis sed foliolis anguste ellipticis longioribus pallide viridescentibus supra mox glabris differt.

Planta perennis? parva, e basi verticillatim ramosa, caulibus prostratis paucis paene simplicibus nunc ad 6 cm. longis ubique adpresse strigillosis viridescentibus. *Folia* trifoliolata; petioli 4–20 mm. longi; foliola perbreviter petiolulata, obovato-cuneata vel elliptica, rotundato-mucronata vel utrinque angustata, terminalia 5–20 mm. longa, 1·5–4 mm. lata, lateralia breviora, supra parcissime adpresse strigillosa, mox glabra, fere enervata, subtus valde adpresse strigillosa, coriacea, laete viridia; stipula solitaria, falcato-lanceolata, acuta, ad 3 mm. longa. *Flores* folio oppositi, solitarii, flavidi; pedicelli fere 2 mm. longi ut calyce strigillosi. *Calyx* 2–2·5 mm. longus, ad medium fissus, lobis subulatis inter se aequalibus. *Vexilli* lamina ungui longior, oblonga vel ovata, obtusa aut acutata, basi fere cordata vel truncata, postice medio pilis deciduis longitudinaliter instructa; alae fere rectae, in toto 5–6 mm. longae, limbis oblongis obtusis basi obtuse sagittatis; ungues gracillimi, limbis triente longiores; carina alis similis nisi latior aut apice rotundata. *Ovarium* ubique valde hirsutulum, stylo glabro ovario dimidio breviore fere genuflexo, stigmate oblique subcapitato. *Legumen* ignotum.

South Africa. Central Region. Graaff Reinet Div.: In a plain near Graaff Reinet, 780 m., *Bolus*, 770!

88. L. TENUIS, Baker, in Oliver's Fl. Trop. Afr. II. 5.

Tropical Africa. Lower Guinea. Angola; Mossamedes, in sandy ground by the River Beco, *Welwitsch*, *Herb. Brit. Mus.* and *Kew!*

89. L. DEPRESSA, Ecklon and Zeyher, Enum. Pl. 178 (1835); Harvey, l.c. 62.

South Africa. Coast Region. George Div.: Between the Gauritz River and Lange Kloof, *Ecklon* and *Zeyher*, 1278. Central Region. Somerset East Div.: Stony places near Little Fish River, 500 m., *MacOwan*, 1686! Graaff Reinet Div.: Grassy hills, Poutlock, near Graaff Reinet, *Mrs. Bowker*, 15!

90. L. FLAVA, Dümmer, species nova, inter *L. depressam*, Eckl. et Zeyh., et *L. pungentem*, Eckl. et Zeyh., sed habitu glabriore, foliolis latioribus fere truncatis nec pungentibus, vexillo toto glabro differt.

Herba perennis, laxe foliata, obscure breviter adpresse strigillosa; caules prostrati, teretiusculi, graciles, ad 15 cm. longi, parce ramosi. *Folia* trifoliolata; petioli ad 5 mm. longi, supra sulcati, subtus convexiusculi, inconspicue strigillosi; foliola cuneata, truncata vel rotundato-truncata, leviter emarginata, rarius mucronulata, terminalia 7–15 mm. longa, 2–3 mm. lata, lateralia horizontalia paulo breviora, supra glaberrima, fere enervata, subtus adpresse strigillosa, deinde fere glabrescentia, subcoriacea, laete virescentia; stipula unica, falcato-subulata, circiter 2·5 mm. longa. *Flores* singuli, foliis oppositi, flavi (fide *Burchell*); pedicelli recti vel interdum fere geniculati, graciles, ad 6 mm. longi, ut videtur ebracteolati. *Calyx* circiter 5 mm. longus, aequaliter quinquefidus, extra strigillosus, fisso inferiore ceteris paullulo angustiore et longiore. *Corolla* glaberrima; vexillum perbreviter unguiculatum, in toto 9 mm., altum, lamina fere orbiculata, apice late triangulare, basi subcordata, dorso carinata; alae perbreviter unguiculatae, limbis fere rectis oblongis 5 mm. longis obtusis basi leviter auriculatis; carina alis similis sed naviculariore. *Ovarium* hirsutum, stylo arcuato glabro. *Legumen* rectum, oblongum, vix turgidum, ad 10 mm. longum, 3–3·5 mm. latum, ad suturam superiorem leviter hirsutum, ceteris glabrum, ad 18-spermum; funiculi filiformes, ad 1 mm. longi.

South Africa. Coast Region. Mossel Bay Div.: Dry hills on the eastern side of the Gauritz River, *Burchell, Herb. Kew*, 6420!

91. L. PUNGENS, Ecklon and Zeyher, Enum. Pl. 177; Harvey, l.c. 62. *L. affinis* and *L. decidua*, Eckl. and Zeyher, l.c.

South Africa. Coast Region. Riversdale Div.: Sandy places near the Gauritz River, *Ecklon* and *Zeyher*, 1279. Bathurst Div.: On hills between Bushman's River and Karrega River, *Ecklon* and *Zeyher*, 1281. Fort Beaufort Div.: Karroid places near Koonap Hills, *Ecklon* and *Zeyher*, 1277. Central Region. Somerset East Div.: Stony places near Somerset East, *MacOwan*, 1143! Graaff Reinet Div.: Stony hills near Graaff Reinet, 540 m., *Bolus*, 446!

92. L. TENELLA, Ecklon and Zeyher, Enum. Pl. 178; Bentham, l.c. 610; Harvey, l.c. 65. *L. tenella*, var. *angustifolia*, Harvey, l.c. *Lipozygis tenella* v. *piloso-villosa*, E. Meyer, l.c. 78. *Leptidium tenellum*, Presl. Bot. Bemerk. 49. *Polylobium tenellum*, D. Dietr. Syn. Pl. IV. 962.

South Africa. Coast Region. Alexandria Div.: Oliphant's Hoek at the Zwartkops River, *Ecklon* and *Zeyher*, 1282! Albany Div.: Fish River Heights, *Hutton !* Central Region. Prince Albert Div.: Great Zwarteberg Range, 900–1200 m., *Drège a !*

Without precise locality. *Mund* and *Maire !* *Zeyher*, 2310!

Among *Drège's* collection of *Lipozygis tenella* there are three small decrepit specimens of an undescribed species, which exhibit an affinity to *Lotononis pumila*, Eckl. and Zeyh.; their leaflets are obovate-cuneate, rotundate or emarginate, subequal among themselves, 5 mm. long, 1·5–2 mm. broad, equals the petiole, or shorter than them, sericeous on both surfaces, greenish and subcoriaceous; stipules? *Flowers* shortly pedicellate, solitary, axillary or opposite to the leaves. *Calyx* hirtellous, membranous, cleft to the middle or lower, 7 mm. long; lobes subequal, narrowly triangular. *Legume* straight, oblong, compressed, 8–9 mm. long, about 20-seeded.

Lack of perfect flowering material prevents an adequate description being offered, but provisionally the species is named *L. decrepita*.

The distribution of *L. tenella* var. *hirsutissima*, Harvey, suggests a closer relationship to *L. calycina*, to which species it is therefore referred.

93. L. ORTHORRHIZA, Conrath, in Kew Bull. (1908), 222.

South Africa. Kalahari Region. Transvaal: Modderfontein, *Conrath*, 121!

Closely allied to *L. tenella*, Eckl. and Zeyh., but differing in the longer calyx-tube, very pilose corolla and legume, which latter equals the calyx.

94. L. VERSICOLOR, Bentham, l.c. 610; Harvey, l.c. 66. *Leptis versicolor* and *L. filicaulis*, Eckl. and Zeyh. l.c. *L. Kraussiana*, Walp. Repert. ii. 837. *Lipozygis Kraussiana*, Meisner, in Hook. Lond. Jour. Bot. II. (1843), 79. *Leptidium versicolor*, Presl. Bot. Bemerk. 49 (1844).

South Africa. Coast Region. Uitenhage Div.: On the fields near the Zwartkops River, *Zeyher*, 485 or 465! 408! Winterhoek, *Krauss, Herb. Zürich !* Albany Div.: Albany, *Mrs. Bowker !*

Meisner's specimens of *Lipozygis Kraussiana*, which I have seen, agree with *Lotononis versicolor*, Benth.

95. L. NEGLECTA, Dümmer, sp. nov. *L. versicolori*, Benth., persimilis sed glabrior, foliolis minoribus obovato-cuneatis perbreviter cuspidatis

crassioribus, floribus paulo minoribus, vexillo auguste oblongo glaberrimo, ovario haud hirsuto recedit.

Herba perennis, humifusa, caulibus divaricato-ramosis ad 10 cm. longis conferte foliatis primo adpresse inconspicue breviter strigillosis mox glabrescentibus atrobrunneis. *Folia* trifoliolata; petiolus 2 mm. longus, mox glabrescens; foliola saepissime conduplicata, auguste cuneata, rotundata, perbreviter reflexo-cuspidata vel acutata, inter se subaequalia, 2·5–4 mm. longa, 1–2 mm. lata, supra medio canaliculata, glaberrima, subtus costata, adpresse breviter strigillosa, sed mox ubique glabra, crassiuscula; stipula minuta, subulata. *Flores* axillares, solitarii aut rarius gemini, oppositi, brevissime pedicellati, probabiliter orangeani. *Calyx* 3–3·5 mm. longus, extra parcissime breviter strigillosus, venosus; dentes superiores 4, subulati, tubo triente longiores, inferiore 2 mm. longo. *Corolla* glaberrima; vexillum unguiculatum, auguste oblongum, utrinque rotundatum prope medio paulo contractum, in toto 5 mm. longum; unguis latus, 1·5 mm. longus; alae fere rectae, oblongae, obtusae, basi paullulo sagittatae, in toto 5 mm. longae; carina alis similis nisi paullulo latior longiorque. *Ovarium* lineare, mox glabrum, fuscum; stylus ovarium aequans aut superans, paulo arcuatus.

South Africa. Coast Region. Uitenhage Div.: Uitenhage, *Pappe, Herb. Kew !*

Represented at Kew by a very small specimen, which has dried a dark brown.

96. L. CARINATA, Bentham, in Hook. Lond. Jour. Bot. II. (1843), 609; Harvey, l.c. 64. *Lipozygis carinata*, E. Meyer, l.c. 80. *Polylobium carinatum*, Bth., in Ann. Wien Mus. II. (1838), 142.

South Africa. Eastern Region. Natal: Between Umzimkulu River and Umkomanzi River, below 150 m., *Drège !*

97. L. FLORIFERA, Dümmer, sp. nov. *L. carinatae*, Benth., affinis sed floribus paulo majoribus numerosioribus saepe umbellatim 2–5-dispositis recedit.

Planta perennis, multiramosa, diffusa, ramis junioribus gracilibus teretibus circiter 10 cm. longis flavidis levibus adpresse pubescentibus senioribus lignescentibus fuscis. *Folia* trifoliolata, internodos aequantia, vel iis saepe multo breviora; petioli 1–3 mm. longi; stipulae gemmatae, falcato-lineares, 1 mm. vix longae; foliola cuneata aut lanceolata, acutata vel mucronata, subaequalia aut intermedia paulo longiora, 5–10 mm. longa, 1–2 mm. lata, dorso molliter sericea, valde costata, supra glabra, herbacea aut leviter coriacea. *Flores* axillares, solitarii vel in umbellas sessiles 2–5-floras dispositi, brevissime pedicellati, flavidi (teste *Wood*), bracteola nulla vel minutissima. *Calyx* 5–6 mm. longus, molliter flavide sericeus, ad medium fissus, lobis superioribus subulatis, lobo inferiore paulo breviore. *Vexillum* cum ungui 9 mm. longum, limbo subreflexo ovato obtusiusculo, basi rotundato aut subtruncato extra valde sericeo-hirsutulo; unguis 2–2·5 mm. longus, glaber; alae 8 mm. longae, limbis auguste oblongis rotundatis basi obtuse sagittatis extra inferne prope marginem sericulis, unguibus gracillimis glabris; *carinae* limbus 5–6 mm. longus, 2·5 mm. latus, fronte paene rotundatus, basi leviter obtuse auriculatus, extra valde sericeo-hirsutulus; ungues angustissimi, glabri, 3–4 mm. longi. *Stylus* arcuatus, glaber, ovario subaequilongus. *Legumen* suboblongum, rectum, compressiusculum, 10 mm. longum, 3 mm. latum, sericulum, 6-spermum, spermis orangeani.

South Africa. Eastern Region. Zululand: N'Tondweni, *Wood, Herb. Kew*, 9284!

98. L. ARIDA, Dümmer, sp. nov. *L. mucronatae,* Conrath, affinis partibus junioribus albo-tomentellis, floribus paulo brevioribus orangeanis, carina curvatiore distinguitur.

Planta perennis, diffuse-prostrata, multiramosa, ubique foliata, ramis gracilibus ad 15 cm. longis, junioribus albo-tomentellis. *Folia* trifoliolata; petioli 3–5 mm. longi, sulcati, primo albo-tomentelli; foliola perbreviter petiolulata, anguste cuneata, acutata, terminalia 3–4 mm. longa, lateralia paulo breviora, juventute albo-tomentella, mox glaberrima, subcoriacea, viridescentia; stipula unica, interdum falcata, lineare, acuta, 1 mm. longa. *Flores* axillares, singuli vel raro gemmati, perbreviter pedicellati, orangeani. *Calyx* 2·5–3 mm. longus, extra albo-sericeus, segmentis superioribus anguste deltoideis circiter 1 mm. longis, inferiore superioribus acuminatiore duplo longiore. *Vexillum* in toto 5–6 mm. altum, limbo ovato apice late triangulare basi subhastato ungui fere duplo longiore postice apicem versus paullulo pubescente; alae anguste oblongae, 4–5 mm. longae, obtusae, obtuse sagittatae, glaberrimae; carina subcurvata, 3–5 mm. longa, 1·5 mm. lata, obtusa, angustissime sagittata, frontem versus parcissime pubescens; ungues gracillimi, 1·5 mm. longi. *Ovarium* tenuiter sericeum, stylo duplo longiore fere recto glabro, stigmate oblique subcapitato.

South Africa. Central Region. Aliwal North Div.: On dry stony flat ground on mountain-tops, Eland's Hoek, 1500 m. near Aliwal North, *Bolus, Herb. Kew*, 10559!

99. L. PUSILLA, Dümmer, sp. nov. *L. aridae*, Dümmer, affinis sed habitu caespitosa, caulibus brevissimis nec albo-tomentellis, foliolis obovato-cuneatis, floribus pallide citrineis, vexillo postice fere omnino sericeo distat.

Herba caespitosa, basi lignosa; radix verticaliter descendens, fusiformis, vix fibrosa, 2·5 mm. crassa; *caules* plurimi, conferti, adpresse prostrati, ad

5 cm. longi, undique adpresse breviter strigillosi, demum glabrati, fusci. *Folia* trifoliolata; petiolus gracilis, foliolis aequalis; foliola perbreviter petiolulata, obovato-cuneata, rotundata, emarginata aut recurvo-mucronata, 2–5 mm. longa, 1·5–2 mm. lata, subtus parce adpresse breviter strigillosa, basin versus costa prominente, supra glaberrima, costa impressiuscula, coriacea; stipula unica, oblique lanceolata, acuta, 1 mm. longa. *Flores* axillares, solitarii, subsessiles aut breviter pedicellati, pallide citrinei. *Calyx* 4·5–5 mm. longus, ultra medium 5-fidus, extra adpresse strigillosus, lobis subaequalibus anguste triangularibus. *Vexillum* breviter unguiculatum, circiter 6 mm. altum, lamina late oblonga subrotundata basi subhastata extra sericula; alae anguste subfalcato-oblongae, 6 mm. longae, rotundatae, basi sagittatae, fere glabrae, unguibus limbo triente brevioribus; carina alis similis sed latior curvatiorque, obtusa, frontem versus parce sericea. *Ovarium* lineare, fere glabrescens, stylo paene geniculato ovario duplo longiore stigmate oblique subcapitato.

South Africa. Central Region. Aliwal North Div.: Slopes of mountains, Eland's Hoek, Aliwal North, 1970 m., *Bolus, Herb. Kew*, 10535!

100. L. MUCRONATA, Conrath, in Kew Bull. (1908), 222.

South Africa. Kalahari Region. Transvaal: Modderfontein, *Conrath, Herb. Kew*, 124! Johannesburg, *Rand, Herb. Brit. Mus.* 675!

With the general facies of *L. Gerrardii*, Dümmer, but with more acute leaflets, slightly longer flowers, and larger legumes.

101. L. GERRARDII, Dümmer, sp. nov. *L. mucronatae*, Conrath, affinis sed habitu laxiuscule diffusiore, ramulis junioribus haud albo-pilosis, foliolis paulo latioribus obovato-cuneatis rotundatis glaberrimis, corollis glaberrimis, leguminibus brevioribus recedit.

Herba perennis, laxe humifusa, basi lignescente, caulibus filiformibus multiramosis circiter 20 cm. longis, lateralibus duplo brevioribus, inconspicue adpresse breviter strigillosis deinde glabris ochraceis aut atrobrunneis. *Folia* trifoliolata; petioli filiformes, foliola et internodiis fere subaequantes; foliola obovato-cuneata, rotundata, interdum mucronulata, rarissime emarginata, intermedia 4–7 mm. longa, 1·5–2·5 mm. lata, lateralia terminalibus paulo breviora aut raro longiora, supra medio canaliculata, utrinque glaberrima, carunculata, vix coriacea, margine incrassata; stipulae singulae, oblique lanceolatae, acutae, 1–2 mm. longae. *Flores* solitarii (raro gemini), folio oppositi aut interdum terminales, fere glabri, pauci, flavidi; pedicelli 2 mm. longi, bracteola minuta. *Calyx* circiter 5 mm. longus, inferne medio fissus, laciniis superioribus subulatis, inferne superioribus paulo longiore lineare-subulata. *Vexillum* spatulatum cum ungui 7 mm. longum, lamina oblonga, acutata, basi hastata; alae breviter unguiculatae, vexillo fere aequilongae, limbis leviter curvatis oblongis obtusiusculis obtuse sagittatis; carina alis similis sed latior. *Legumen* rectum, oblongum, complanatum, frontem versus subampliatum, 8 mm. longum, glabrum, laeve, ochraceum, 6-spermum.

South Africa. Eastern Region. Natal and Zululand. Without precise locality, *Gerrard, Herb. Kew* and *Brit. Mus.*, 1075!

Var. TRANSVAALENSIS, Dümmer, typo minor et primo pagina inferiore foliorum adpresse breviter strigillosa, floribus sericulis differt.

Kalahari Region. Transvaal: Near the Klein Oliphants River, 1530 m., *Schlechter, Herb. Zürich* and *Kew*, 3809!

A small appressedly prostrate herb, 5–10 cm. in diameter, differing principally from the species in the lower surfaces of the leaves being covered at first with minute adpressed stiff hairs, and the flowers, which are inconspicuously sericeous.

102. L. HUMIFUSA, Burchell ex Bentham, l.c. 609; Harvey, l.c. 64. *Lipozygis humifusa*, E. Meyer, l.c. 77. *Polylobium humifusum*, Dietr. Syn. Pl. IV. 962.

South Africa. Coast Region. Bathurst Div.: Riet Fontein and vicinity, between Kasuga River and Port Alfred, *Burchell*, 3927! Albany Div.: Fish River heights, Albany, *Hutton!* in the plains near Grahamstown, *MacOwan*, 6!

Var. RADULA, Harvey, l.c. *Lipozygis radula*, E. Meyer, l.c. 77. *Polylobium radulum*, Dietr, Syn. Pl. IV. 962.

Central Region. Albert Div.: Albert, *Drège, Herb. Sond.*

103. L. REHMANNII, Dümmer, sp. nov. *L. humifusae*, Burch., affinis a qua ramulis hirtellis, stipulis majoribus, floribus paullulo minoribus, calyci hirtello distinguitur.

Herba perennis, humifusa, multiramosa, caulibus ad 25 cm. longis teretiusculis hirtellis conferte foliatis. *Folia* trifoliolata, stipulata, subsessilia vel petiolis ad 3 mm. longis suffulta; foliola elliptica vel obovata, apiculata, intermedia ad 6 mm. longa, 2–3 mm. lata, lateralia paulo breviora, supra glabrescentia, subtus parce hirtella, mox utrinque glabra, costa prominula, fere chartacea, laxe ciliata; stipula ovata, breviter cuspidata, 1·5 mm. vix excedens. *Flores* terminales aut oppositifolii, solitarii, aut bini subsessiles, sicco citrinei. *Calyx* 7 mm. longus, extra parce sulphureo-hirtellus, ultra medium fissus, fissis acuminatis. *Vexillum* unguiculatum, spatulatum, lamina ungui aequilonga, acutata, basi rotundata, postice medio sericea; alae longe unguiculatae, 8 mm. longae, laminis falcato-oblongis rotundatis basi obtuse auriculatis; carina alis latior longiorque, ad frontem paullulo hirtella. *Ovarium* hirsutulum; stylus arcuatus, superne glaber.

South Africa. Kalahari Region. Transvaal: Hogge Veld, Perekopberg, *Rehmann, Herb. Zürich* and *Kew*, 6831!

A species exhibiting affinities to *L. calycina*, Benth. and *L. humifusa*, Burch., respectively, but differing from the former in the almost glabrous carina, which exceeds the calyx in length, and though having a resemblance to the latter, the shorter flowers and hairy calyx distinguish it from that species immediately.

104. L. ORNATA, Dümmer, sp. nov. *L. humifusae*, Burchell, affinis ab floribus minoribus, vexillo breviter unguiculato, limbo oblongo fere glabro, carina latiore glabra distinguitur.

Planta perennis, humifusa, caulibus ad 15 cm. longis parcissime adpresse pubescentibus aut mox glabris, ochraceis; ramuli laterales, breves, plurimi, valde foliati floriferique. *Folia* trifoliolata; petioli stipulam aequantes vel duplo superantes; foliola obovato-cuneata, apice rotundata, lateralia 3 mm. longa aut minora, terminalia paulo majora, supra glaberrima, subtus sericula, demum glabrescentia, fere enervata, crassiuscula; stipula unica, subulata, 1 mm. vix excedens. *Flores* axillares vel ramulos laterales brevissimos terminantes, singuli, subsessiles, sicco pallide straminei. *Calyx* 5 mm. longus, extra sericulus, venosus, dentibus superioribus triangularibus 1 mm. longis, inferiore duplo longiore. *Vexillum* perbrevitur unguiculatum, in toto 9 mm. altum, lamina late oblonga vel late ovata, obtusa aut acutata, basi fere truncata, postice ad carinam pilis instructa; alae 6–7 mm. longae, glabrae, limbis paulo curvatis oblongis rotundatis basi obtuse sagittatis, unguibus limbis duplo aut tertio longioribus; carina alis similis, nisi paulo longior et latior, basi anguste sagittata; ungues gracillimi. *Ovarium* lineare, frontem versus et ad suturum superiorem hirsutulum, stylo curvato superne glabro, stigmate oblique subcapitato.

South Africa. Kalahari Region. Basutoland; without further indication as to locality. *Cooper, Herb. Kew*, 745!

105. L. MICROPHYLLA, Harvey, l.c. 65.

Coast Region. Queenstown Div.: Plains near Queenstown, 1050 m., *Galpin*, 2334! Shiloh, at Upper Klipplaat, 1200 m., *Baur*, 871!

Without precise locality. *Zeyher, Herb. Sonder.*

106. L. AMBIGUA, Dümmer, sp. nova. *L. microphyllae*, Harvey, affinis sed foliolis apice rotundatioribus calyce corollam fere aequante distinguitur.

Suffruticosus humifusus, divaricato-ramosus, dense foliatus floriferusque, inconspicue breviter adpresse strigillosus, caulibus lignescentibus ad 20 cm. longis. *Folia* trifoliolata; petioli 1–2 mm. longi, teretiusculi; foliola late cuneata, rotundata, saepissime mucronulata, petiolos aequantia aut paulo superantia, aequalia vel terminalia leviter longiora, supra glabra, subtus breviter adpresse strigillosa et medio costata, coriacea; stipula unica, falcato-subulata, minuta. *Flores* singuli vel bini, axillares aut ad ramulos laterales brevissimos dispositi, perbreviter pedicellati, pallide sulphurei. *Calyx* 5 mm. longus, extra sericulus, ad medium fissus, laciniis subulatis subaequilongis. *Vexillum* unguiculatum, 5 mm. altum, lamina ovata acuta subhastata postice sericula, ungui latiusculo fere duplo longiore; alae leviter curvatae, anguste oblongae, 5–6 mm. longae, obtusae, truncatae; carina fere recta, alis similis nisi latior inconspicue sericula, mox glabra. *Ovarium* stylum crescentem aequans. *Legumen* rectum, oblongum, subturgidum, 5 mm. longum, inferne parce sericeum, ochraceum, seminibus 8–10.

South Africa. Coast Region. Somerset East Div.: Fields near Somerset East, 500 m. *MacOwan,* 1739! Eastern Region. Natal: Boschberg, 900 m., *MacOwan,* 2022, partly!

107. L. CALYCINA, Bentham, l.c. 610. *L. tenella,* var. *calycina,* Harvey, l.c. 651. *L. divaricata,* Ecklon and Zeyher ex Harvey, l.c. *Leptis divaricata,* Eckl. and Zeyh. l.c. 175. *L. calycinum,* Benth. in Ann. Wien Mus. II., (1838), 142. *Lipozygis calycina,* E. Meyer, 78 (in part). *Leptidium calycinum,* Presl. Bot. Bemerk. 49; *Polylobium calycinum,* D. Dietr. Syn. Pl. IV. 962.

South Africa. Coast Region. Stockenstroom Div.: Kat Berg, 1200–1500 m., *Drège a!* King Williamstown Div.: Sandy slopes near King Williamstown, 540 m., *Tyson, Norm. Aust.-Afr.* 852! In fields near Somerset East, *MacOwan,* 2022, partly! Kalahari Region. Orange River Colony: Vaal River, *Burke!* Thaba Unchu, *Burke,* 436! *Zeyher,* 406! Eastern Region. Natal: Hoffenthal, Upper Tugela, *Wood,* 3535! *Gerrard,* 1733, partly! Bank of Tugela, Weenen County, *Wood,* 3548! Near Maritzberg, *Wood,* 3164! *Mrs. K. Saunders!*

Var. HIRSUTISSIMA, Dümmer, comb. nov. *L. tenella,* var. *hirsutissima,* Harvey, l.c.

Kalahari Region. Transvaal: Magaliesberg, *Zeyher,* 407! *Burke!* Pretoria, near Wonderboompoort, *Rehmann,* 4599! 6215! Bechuanaland Div.: Near pass in the Kuruman Hills, *Burchell,* 2175!

Var. ACUTA, Dümmer, var. nov. a typo foliolis ellipticis acutatis nec rotundatis, floribus paulo majoribus distinguenda.

Habit of the species, but more floriferous; leaflets more or less elliptic, subacute, tapering to the base into scarcely perceptible petiolules, 5–8 mm.

long, 1·5–3 mm. broad, the terminal leaflets slightly exceeding the lateral ones. *Flowers* solitary or in pairs, invariably opposite the leaves, shortly pedicellate, yellow; bracteoles two, opposite, subulate. *Calyx* equally divided half-way, about 10 mm. long, densely fulvously pilose; carina scarcely exceeding the calyx in length, and slightly appressedly pubescent in front.

Kalahari Region. Transvaal: Lydenburg, *Wilms*, 272! 273! Orange River Colony. *Cooper*, 863! Landsbergs, about 20 miles from Middelburg, 1440 m., *Bolus*, 7709! Eastern Region. Natal: Valley of the Buffalo River near Charlestown, 1500–1600 m. *Wood*, 4796! Hillsides near Mooi River, 1200 m., *Wood!* near Maritzburg, *Wood*, 587! between Pietermaritzburg and Newcastle, *Wilms*, 1924!

As a result of a wide diffusion this species is most variable and difficult of limitation, but an examination of a series of specimens offer no justification for any separation, except where proposed. Var. *major* approximates very closely to *L. calycina*, v. *acuta*, but the tufted, erect habit of the annual shoots of the former is very characteristic. All the forms agree in having the calyx nearly as long as the carina, while the seeds are in all cases a brick-red; the indumentum is variable.

108. L. Dregeana, Dümmer, sp. nov. ab affini *L. calycina*, Benth., foliolis floribusque minoribus et carina calycem superante, distinguitur.

Suffruticosus prostratus, pumilus, sordidus, parce ramosus, sericeo-pilosus; caules ad 5 cm. longi, foliosi. *Folia* trifoliolata; petioli ad 2 mm. longi; foliola elliptica vel obovata, rotundata aut acutata, basin versus attenuata, ad 3 mm. longa, 1·5–2 mm. lata, lateralia aequilonga aut breviora, supra mox glabra; subtus sericeo-pilosa, vix coriacea; stipula una, parvula. *Flores* oppositifolii, solitarii, pauci, breviter pedicellati, probabiliter flavidi. *Calyx* 5 mm. longus, extra sericeus, lobis acutis tubo aequalibus. *Vexillum* unguiculatum, spatulatum, 6–7 mm. altum, acutatum, limbo dorso sericeo; alae breviter unguiculatae, fere glabrae, limbis oblongis rotundatis basi truncatis aut obtuse sagittatis; carina alis similis sed lamina naviculari sagittatiore ad margines inferiores ciliolata. *Ovarium* hirsutulum; stylus prorso arcuatus, stigmate subcapitato. *Lipozygis calycina*, var. *b.* E. Meyer, l.c.

South Africa. Coast Region. Queenstown Div.: Shiloh, 1050–1200 m. *Drège!*

Bentham, in describing *L. calycina*, alludes to this species, which is represented at Kew by a small specimen, and opines that it is probably distinct.

The following species, owing to their straight styles and correlated straight carinae, or their rostrate carinae, subequally 5-fid calyces and occasional turgid pods, are referred to the genera *Pearsonia* and *Crotalaria* respectively. (Recent collectors' numbers are appended.)

1. L. acutiflora, Bentham = Crotalaria quinata, E. Meyer.
2. L. arenicola, Schlechter = Crotalaria arenicola, Dümmer, comb. nov.
   Schlechter, 11206.
3. L. aristata, Schinz = Pearsonia aristata, Dümmer.*
4. L. filifolia, Bolus = Pearsonia filifolia, Dümmer.
5. L. Haygarthii, N. E. Br. = Pearsonia Haygarthii, Dümmer.
6. L. lenticula, Bentham = Crotalaria lenticula, E. Meyer.
   Burchell, 1455! *Bolus*, 768! *Johanssen*, 24!
7. L. marginata, Schinz = Pearsonia marginata, Dümmer.
8. L. micrantha, Harvey = Crotalaria micrantha, E. Meyer.
   Bolus, 7518! 8970! *Bachmann*, 2227!
9. L. multiflora, Schinz = Pearsonia multiflora, Dümmer.
10. L. namaquensis, Bolus = Crotalaria namaquensis, Dümmer, comb. nov.
   Bolus, 6569! *Schlechter*, 11185! Very similar to *C. lenticula*, E. Mey., but inflorescences subumbellately 3–12-flowered.
11. L. oxyptera, Bentham = Crotalaria oxyptera, E. Mey.
   Bolus, 5473! 12650! *Wolley Dod*, 1594!
12. L. perplexa, Eckl. and Zeyh. = Crotalaria perplexa, E. Meyer.
   Schlechter, 9195! 11046!
13. L. Rogersii, Kensit = Pearsonia Rogersii, Dümmer.
14. L. sessilifolia, Harv. = Pearsonia sessilifolia, Dümmer.
15. L. swaziensis, Bolus = Pearsonia swaziensis, Dümmer.

Excluded Species.

Lotononis densa, Harvey = Lebeckia densa, Thunb.
L. Wrightii, Harvey = Hallia asarina, Thunb.

PLEIOSPORA, Harvey, Thes. Cap. 51, t. 81 (1859).

A group of nine species, wholly South African, confined to the Transvaal and Natal Regions. With the exception of three species, they

* Cf. *Journal of Botany* (1912), pp. 353–358.

develop straight robust annual flowering shoots from a perennial woody rhizome, the flowers, which are invariably yellow, being variously disposed.

I. Annual flowering shoots rigid, straight, and erect.
  *i*Flowers congested in hemispheric or oblong heads.
    *Leaflets thickly and densely ferruginously hirsute-sericeous.
      Leaflets elliptic, subacute; lateral nerves prominent but the intervening veinlets inconspicuous. Vexillum slightly sericeous posticously. .. .. (4) *holosericea.*
      Leaflets narrowly obovate, rounded at the apex, prominently netted beneath. Vexillum glabrous. .. .. .. (5) *Bolusii.*
    **Leaflets sparingly sericeous or pubescent.
      Leaves densely imbricate. Heads many, densely-flowered. Habit robust. .. .. (1) *cajanifolia.*
      Leaves scarcely imbricate. Heads few, 2–3-flowered. Habit slender. .. .. (3) *gracilior.*
  *ii*Flowers disposed in paniculately branched spiciform racemes.
    Leaflets thickly hirsute-sericeous, elliptic-acuminate. .. (2) *paniculata.*
II. Annual flowering shoots decumbent, sinuate.
  a. Stipules filiform or subulate. Spiciform racemes compactly flowered.
    †Leaflets elliptic, 7 cm. long, thickly coriaceous, and densely ferruginously sericeous. .. .. (7) *macrophylla.*
    ††Leaflets obovate, 3 cm. long, thinly coriaceous, with scattered hairs, prominently veined and bullatulate. .. (6) *obovata.*
  b. Stipules obliquely ovate, cuspidate. Racemes elongate, often secund, more or less laxly flowered.
    *Pedicels 1–1½ mm. long. Bracteoles subulate, inconspicuous. .. .. (8) *grandifolia.*
    **Pedicels 3–4 mm. long. Bracteoles broadly ovate or reniform, cuspidate, enveloping the lower portion of the calyx .. .. (9) *latebracteolata.*

1. Pleiospora cajanifolia, Harvey, Thes. Cap. I. 51, t. 81; l.c. 47. *Psoralea cajanifolia*, Benth. ex Harvey, l.c.

Kalahari Region. Transvaal: Magaliesberg, *Burke*, 58! *Zeyher*, 448! Near Lydenburg, *Atherstone!* Hillsides near Barberton, 900 m., *Thorncroft* 36, ex *Herb. Wood*, 4158! Wonderfontein, *Nelson*, 528! Modderfontein, *Conrath*, 120! Heidelberg, *Miss R. Leendertz*, 1074! Pretoria, *Fehr, Herb. Schinz!* Eastern Region. Natal: Natal, *Wood,* 4158! *Gerrard*, 116!

2. P. paniculata, Bolus, MSS. ab affini *P. cajanifolia*, foliolis longe acuminatis, stipulis brevioribus, floribus paullulo minoribus racemoso-paniculatim (haud in capitula) dispositis, distinguitur.

Frutex, altus? partibus junioribus ubique corollis exceptis hirsutulis, ramulis florentibus erectiusculis subangulatis aut teretibus foliatis. *Folia* trifoliolata; petioli ad 12 mm. longi, fere cylindrici; foliola lanceolata, utrinque angustata aut apicem versus longe acuminata, apiculata; terminalia ad 5·5 cm. longa, 1·5 cm. lata, lateralibus longiora aut duplo longiora, subtus costa nervisque lateralibus prominentibus intra marginem anastomosantibus, supra fusciora, haud reticulata, subcoriacea; stipulae binae, arrectae, lineari-subulatae, 3 mm. longae. *Paniculae* ad 8 cm. altae, parce ramosae, ramulis lateralibus patente-ascendentibus ad 4 cm. longis paucifloris; flores perbreviter pedicellati, vix congesti, pallide lutei (fide *Bolus*); bractea subulata, 4 mm. longa; bracteolae binae, oppositae, filiformes, 2–2·5 mm. longae. *Calyx* inflatus, 7 mm. longus, extra stramineo-hirsutulus, ad medium fissus, lobis anguste triangularibus. *Vexillum* 10 mm. altum, limbo oblongo fere truncato basi in unguem abrupte angustato, postice ubique parcissime sericulo intra inferne sericulo; alae vexillo aequilongae, rotundatae, basin versus in unquem longiusculum angustatae, glabrae; carina 7 mm. longa, alis similis, sed angustior, acutata, glabra. *Ovarium* oblique ovatum, pubescens, pluriovulatum, frontem versus in stylum rectum glabrum attenuatum.

Kalahari Region. Transvaal: On mountain-slopes, Houtbosch 1470 m., *Bolus*, 11034!

3. P. GRACILIOR, Dümmer, sp. nov. a *P. cajanifolia*, Harvey, habitu graciliore, foliolis brevioribus glabrioribus vix prominente reticulatis, capitulis paucioribus 2–3-floris distincta.

Rami graciles, ad 30 cm. alti, erectiusculi, fere simplices, compressiusculi, laxe foliati, internodiis ad 30 mm. longis, parce adpresse strigillosi. *Folia* ascendentia, trifoliolata; petioli ad 20 mm. longi, teretiusculi; foliola perbreviter petiolulata, elliptica aut oblanceolata, rotundato-acutata, perbreviter cuspidata, a medio basin versus sensim angustata, terminalia 4 cm. longa, 1·5 cm. lata, lateralia aequilonga aut paulo breviora, subtus costa prominente, nervis lateralibus prominulis, utrinque parce pilosula, tenuiter coriacea; stipulae binae, filiforme-subulatae, erectae, 4 mm. longae. *Inflorescentia* axillaris aut terminalis, 2–4-flora, pedunculo ad 15 mm. alto; flores perbreviter pedicellati, flavidi? bracteolae binae, subulatae, ad 4 mm. longae. *Calyx* inflatus, 6–7 mm. longus, extra fulvido-sericeus, dentibus superioribus oblique detoideis 2–2·5 mm. longis, dente inferiore deltoideo-acuminato. *Vexillum* breviter unguiculatum, toto 8–9 mm. altum, limbo late oblongo utrinque fere truncato, postice medio parce sericulo; alae 8 mm. longae, glabrae, limbis conduplicatis fere ellipticis rotundatis unquibus aequilongis; carina alis similis sed angustior, acutata, glabra. *Ovarium* valde hirsutulum, stylo glabro duplo brevius.

Kalahari Region. Transvaal: Without precise locality. *McLea* ex *Herb. Bolus*, 5621! (*Herb. Kew!*).

4. P. HOLOSERICEA, Schinz, in Bull. Herb. Boiss. VII. 29.

Kalahari Region. Transvaal: Lydenburg, *Wilms*, 264! 264a! Houtbosch, *Rehmann*, 6270! Makapansberge, Streydpoort, *Rehmann*, 5552!

Allied to *P. cajanifolia*, Harv., but distinguished by the denser foxy indumentum, and more compact inflorescences. The numbers quoted are both at Kew and Zürich.

5. P. BOLUSII, Dümmer, sp. nov. *P. holosericeæ*, Schinz affinis nisi foliolis oblanceolato-ovatis subtus prominente retibus, floribus paullulo majoribus, vexillo superne glabro differt.

Frutex unimetralis altus? ubique corollis exceptis fulvido crasse hirsuto-sericeus, ramis angulatis superne dense foliatis. *Folia* trifoliolata; petioli ad 20 mm. longi, fere 2 mm. crassi; foliola oblanceolato-ovata, rotundata, saepissime mucronata, terminalia perbreviter petiolulata, 6 cm. longa, 2 cm. lata, lateralia sessilia, paullulo breviora, subtus valde prominente reticulata, supra laevia, fusciora, valde coriacea; stipulae binae, erectiusculae, filiformi-subulatae, 6 mm. longae. *Flores* perbreviter pedicellati, umbellatim congesti, ramulos terminales vel laterales terminantes; bractea filiformi-subulata, 4 mm. longa; bracteolae gemmatae, similes nisi breviores. *Calyx* 8 mm. longus, extra stramineo-hirsutulus, ultra medium fissus, lobis superioribus deltoideo-acuminatis, lobo inferiore paullulo longiore. *Vexillum* in toto 12 mm. altum, lamina late oblonga, rotundata aut truncata, postice medio ut ungui cuneato sericula; alae unguiculatae, glaberrimae, limbis conduplicatis oblique oblongis rotundatis 7–8 mm. longis; carina fere recta, toto 10 mm. longa, glabra, limbo anguste oblongo unguibus gracilibus aequilongo. *Ovarium* valde hirsutum, apicem versus in stylum perbrevem angustatum, toto 8 mm. altum, stigmate horizontaliter subcapitato.

Kalahari Region. Transvaal: Rocky mountains, Houtbosch, Pietersburg District, 1740 m., *Bolus*, 10995!

6. P. OBOVATA, Schinz, l.c. 29.

Kalahari Region. Transvaal: Houtbosch, *Rehmann*, *Herb. Zürich* and *Kew*, 6249!

Var. BREVEPEDUNCULATA, Dümmer, nov. var. a typo foliolis crassioribus, petiolis et pedunculis brevioribus, spicis hemisphericis aut late cylindricis distinguenda.

Kalahari Region. Transvaal: *Roe* ex *Herb. Bolus* and *Kew*, 2639! MacMac, *Atherstone!*

Petioles 1–3 mm. long. Peduncles 0·5–3 cm. long. Spikes hemispheric or broadly cylindric, 2–2·5 cm. in diameter.

7. P. MACROPHYLLA, Dümmer, sp. nov. *P. obovatae*, Schinz, similis sed foliolis majoribus ellipticis, stipulis filiformi-subulatis recedit.

Herba perennis, scandens? ferrugineo-sericeo-hirsuta, caulibus angulatis sulcatis, internodiis ad 4 cm. longis. *Folia* subsessilia aut petiolata, trifoliolata; petioli usque ad 10 mm. longi, crassi; foliola late elliptica, utrinque sensim angustata, perbreviter cuspidata aut mucronata, terminalia ad 7 cm. longa, 2·2 cm. lata, lateralia fere duplo minora, subtus valde reticulata, supra leviora et fusciora, coriacea; stipulae binae, filiformi-subulatae, 8 mm. longae. *Racemi* axillares aut terminales, longe pedunculatis, floribus in capitulis oblongis valde aggregatis; pedunculus subnudus, ad 45 mm. longus; capitula ad 35 mm. longa, 15 mm. lata; flores perbreviter pedicellati; bracteolae binae, oppositae, 2 mm. vix excedentes. *Calyx* ad 6 mm. longus, ad medium fissus, segmentis superioribus subulatis, segmento inferiore paulo breviore, extra fulvo-hirsutus, coriaceus. *Vexillum* toto 9 mm. altum, limbo oblongo utrinque rotundato in unquem brevem attenuata, extra inferne et medio adpresse fulvo-hirsuto; alae ad 10 mm. longae, anguste oblongae, rotundatae, in unquibus brevioribus angustatae; carina alis similis sed unquibus limbo aequilongis, fere glabra. *Ovarium* valde hirsutum, stylo recto glabro aequilongum.

Kalahari Region. Transvaal: MacMac, Lydenburg, *Atherstone !*

The coriaceous, thickly felted ferruginous large elliptic leaves characterise this species and distinguish it from its immediate ally, *P. obovata*, Schinz.

8. P. GRANDIFOLIA, Dümmer, comb. nov. *Lotononis grandifolia*, Bolus, in Jour. Bot. (1896), 19; Wood, Natal Plants, I. t. 9.

Eastern Region. Natal: On grassy slopes, Van Reenen's Pass, 1750 m., *Wood*, 4516! Rocky hills, York, *McKen*, 8! *Gerrard*, 1103! Kalahari Region. Orange River Colony: *Cooper*, 866!

A remarkably distinct plant, which by its large leaflets, paired stipules, horizontal concave standard, straight keel and style, exhibit a greater affinity to this genus than to that accorded it by Bolus. The large flowers, which are invariably disposed in secund racemes, are, according to Mr. Medley Wood, a dull purple, the upper margin of the standard being prettily fimbriated. In its general habit it is very similar to the preceding species, but the relatively larger, fewer flowers, and the three distinct bracteoles investing the bases of the calyces, render it easy of identification.

9. P. LATEBRACTEOLATA, Dümmer, sp. nov. facie *P. grandifoliae*, Dümmer, similis sed omnino hirsutior, floribus longius pedicellatis, paulo majoribus, bracteolis magnis distinctis differt.

Planta ut videtur scandens (perennis) undique corollis exceptis adpresse hirsuta. *Caules* compressiusculi, internodiis circiter 2·5 cm. longis. *Folia* magna, trifoliolata; petioli 5–20 mm. longi; foliola late elliptica aut obovata, apice rotundata, breviter cuspidata vel mucronata, inferne a medio sensim angustata, 20–55 mm. longa, 20–30 mm. lata, coriacea, subtus costa nervisque lateralibus prominulis, supra costato-impressa; stipulae binae, fere persistentes, ascendentes vel demum deflexae, oblique lanceolatae aut late obovatae, longe vel breviter cuspidatae, basi rotundatae vel subcordatae, 4–7 mm. longae. *Racemi* terminales, secundi, 6–9-flori; flores patentes, laxe dispositi vel congesti, pedicellis 3–4 mm. longis suffulti; bracteolae 3, calycis basin fere amplectrantiae, late ovatae, fere orbiculares aut transverse ellipticae, oblique abrupte cuspidatae, basi rotundatae, 6–10 mm. longae, extra hirsutae, intra mox glabrescentes. *Calyx* 15 mm. longus, segmentis superioribus 4, in unum bilobum marginibus irregulariter dentatis connatis, segmento inferiore anguste deltoideo circ. 6 mm. longo, extra valde fulvido pubescens, intra inferne glabrescens sed superne parce pubescens, coriaceus. *Vexillum* perbreviter unguiculatum, lamina late oblonga, utrinque rotundata, apice fimbriata, 20 mm. alta, fere 10 mm. lata, postice superne parce adpresse fulvo sericea sed basin versus glaberrima; alae 14 mm. longae apicem versus valde curvatae ampliataeque, basin versus in unques brevos sensim augustatae, extra ad marginum infernem fulvido sericeae; carina longe unguiculata, recta, lamina 7 mm. longa, 2·5 mm. lata, glaberrima. *Pistillum* stylo recto excepto fulvo-hirsutum.

Kalahari Region. Transvaal: Spitzkop, Gold-mine near Lydenburg, *Wilms*, 392! Near Lydenberg, *Atherstone!* Elandspruit Berg, 2250 m., *Schlechter*, *Herb. Zürich*, 3838!

West, Newman proc.

LOTONOMIS LEUCOCLADA, (*Schlechter*) *Dümmer*, comb. nov. Nat. size.
1. Calyx, laid open. 2. Vexillum. 3. Ala. 4. Carina. 5. Pistil. All enlarged.

NOTE ON THE NEWCOMB OPERATORS USED IN THE DEVELOPMENT OF THE PERTURBATIVE FUNCTION.

By R. T. A. Innes.

(Received February 27, 1913.)

(Read April 16, 1913.)

In my paper on the algebraical development of the elliptic perturbative function (Transactions, vol. ii., part 3, pp. 301–317, 1911) certain recurrence formulae were given by which the Newcomb operators involved could be built up from those of a lower order. As therein remarked, Newcomb and Chessin had already done the same, but the advantage in my method was the brevity of the calculations and the disclosure of the recurrence-law which permitted the indefinite extension for primary and secondary terms. I now add two tables which will include all the most important tertiary terms (namely, all those under the 6th order of the excentricities).

Herr G. v. Zeipel has recently published a paper on these operators (Arkiv för Mathematik, Astronomi och Fysik, Stockholm, Band 8, No. 19, 1912), which gives a very simple analytical solution of the problem. He has found—

$$4q\underset{(i)}{\Pi_q^q} = (-2D+4i)\underset{(i+1)}{\Pi_{q-1}^{q-1}} + (-D+i)\underset{(i+2)}{\Pi_{q-2}^{q-2}}$$

and expressions of the same nature for Π_q^{q+2} and Π_q^{q+4}.

If explicit developments in terms of D and i are required, these are the most convenient expressions yet derived, but in practical use they suffer from a disadvantage which the older recurrence formulae avoid. Herr v. Zeipel's formulae only build up the operators, and it is therefore necessary to introduce the i's as has been done, whilst the others build up both operator and its object. These operators, when numerical applications are made, must be attached to the $a'A_i$ of the perturbative function.

TABLE IV.A.

Tertiary Terms.

	$\Pi_{0,n}^{0,n'}$.	$2\Pi_{1,n}^{1,n'}$.	$8\Pi_{2,n}^{2,n'}$.	$48\Pi_{3,n}^{3,n'}$.	$384\Pi_{4,n}^{4,n'}$.	$3840\Pi_{5,n}^{5,n'}$.
$8\Pi_{-2,n}^{2,n'}$	$+2(8i^2+5i+0)$	$+8(i-0)$	$+1$			
$16\Pi_{-1,n}^{3,n'}$	$-8(3i^2+i+0)$	$+2(8i^2-14i+2)$	$+8(i-1)$	$+1$		
$64\Pi_{0,n}^{4,n'}$	$-2(7i^2+i+0)$	$-8(6i^2-7i+2)$	$+2(8i^2-33i+24)$	$+8(i-2)$	$+1$	
$384\Pi_{1,n}^{5,n'}$	$-8(7i^2+i+0)$	$-2(21i^2+9i+0)$	$-8(9i^2-24i+17)$	$+2(8i^2-52i+66)$	$+8(i-3)$	$+1$

TABLE IV.B.

Tertiary Terms.

For $\Pi_{m,q}^{m',q+4}$. Interchange m and n, and replace i by $-i$.

N.B.—The i^2 can be replaced by D quantities, thus—

$$8\Pi_{-2,n}^{2,n'} = 8\Pi_{2,n}^{2,n'} + 4D2\Pi_{1,n}^{1,n'} + 2(5i+2D)\Pi_{0,n}^{0,n'}.$$

In other words, although we can with Herr v. Zeipel write symbolically (putting $q=2$)—

$$8\underset{(i)}{\Pi_2^2} = (-2D+4i)\underset{(i+1)}{\Pi_1^1} + (-D+i)\underset{(i+2)}{\Pi_0^0}$$

we cannot write—

$$8\Pi_2^2 a'A_i = (-2D+4i)\Pi_1^1 a'A_{i+1} + (-D+i)\Pi_0^0 a'A_{i+2}$$

although we can write—

$$8\Pi_2^2 a'A_i = (-2D+3-2i)\Pi_1^1 a'A_i + i\Pi_0^0 a'A_i$$

as given in my paper above referred to.

In a methodical application to the theory of the motion of any planet, we require $\underset{(i)}{\Pi_0^0} a'A_i$, then $\underset{(i)}{\Pi_1^1} a'A_i$, and so on, and once in possession of these, we proceed to $\underset{(i)}{\Pi_2^2} a'A_i$, &c. This is the great advantage of the recurrence formulae which keep to $\underset{(i)}{\Pi_q^{q+2m}}$, in which the suffix i remains the same. It would be very nice to have expressions in which $\underset{(i+j)}{\Pi_q^{q+2m}}$ depended on numbers inferior to $i+j$, but so far no general expression which would facilitate numerical work has been offered. A type of such an expression is—

$$4\underset{(i+2)}{\Pi_0^2} = 4\underset{(i)}{\Pi_0^2} - (i+2)(3i+5)a'A_{i+2} + i(3i-1)a'A_i$$

in which Π_0^2 for $i+2$ is built up from the value for i plus simple multiples of $a'A_i$ and $a'A_{i+2}$.

JOHANNESBURG,
February 21, 1913.

TRANSACTIONS

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OF THE

ROYAL SOCIETY OF SOUTH AFRICA.

VOLUME III.—PART 3. (*Final.*)
1913.

CAPE TOWN:
PUBLISHED BY THE SOCIETY.

1913.

Issued November 14th, 1913.] [Price 10s.

CONTENTS.

THE "PLATHANDER" (*XENOPUS LAEVIS*).

By T. F. Dreyer, B.A., Ph.D.

(Received April 4, 1913.)

The present article is an attempt to describe the Plathander, or Horned Toad, with special reference to those points in which it differs from the frog (*Rana temporaria*). I have not had access to any literature except to Gadow (Cambridge Natural History), but consider the publication of my observations are warranted by the fact that Xenopus is mostly used as a laboratory type in South Africa on account of the difficulty of obtaining frogs. If there is any literature on the anatomy of Xenopus, apart from Gadow, it is not readily accessible here.

Systematic Position.—The genus Xenopus is confined to Africa, and is represented by three species, of which only one (*X. laevis*) occurs in the Union (Gadow); the above species is characterized by the absence of a metatarsal spur and by the smallness of the tentacles. *X. muelleri* occurs in Zanzibar and Benguela, while *X. calcaratus* is found in Tropical West Africa.

Habits.—The Plathander lives in water which never or seldom dries up; it frequents the muddy bottoms of such pools, and can stay under water for prolonged periods without coming up to breathe. It is an omnivorous feeder, but it is strange that Daphnids can always (and Apus sp., Estheria-like crustacea, water-boatmen, and Cyclops occasionally) be found in dams swarming with Plathanders, whereas I have not yet found mosquito larvae with Plathanders. In captivity they seize these larvae greedily. In individuals which I kept for a few months in clear water, I found, on dissection, that the stomachs were fairly full of small algae. At Bloemfontein I found the females filled with, apparently, matured eggs already in August, but eggs were not laid until after the breaking of the drought at the end of December. The tadpoles were found both in the large dams and in the Bloem Spruit, and were apparently more numerous in the latter. This may, however, be due to the fact that here they are more easily netted than in the full dams. At Oudtshoorn I found tadpoles finishing their metamorphosis early in December. The method of feeding is peculiar. The small fore-limbs are each provided with four stiff digits (unclawed);

with these the animal makes rapid scooping movements in the mud and makes quick darts at, and swallows, any food which it causes to be suspended in the water in this way. Animals swimming at the surface are pounced upon and swallowed with wonderful rapidity. If the morsel of food is too large to be swallowed the fore-limbs are again brought into use; portions of the captured prey is made to project from the mouth, and the Plathander makes vicious jabs at it with first one hand then with the other until it is reduced to a suitable size.

External Appearance.—The body is smoothly oblong in cross-section and is largest posteriorly—it gradually tapers towards the anterior end; the head is flattened. The cloaca is terminal posteriorly and, in the female, is provided with three conspicuous folds of skin. There are no distinctly coloured tympanic membranes. The eyes are round, protruding organs; the mouth has not such a wide gape as in the frog and there is no tongue. The tentacles, situated just below the eyes, are very small, and are only distinctly noticeable when the animal is under water. The fore-limbs are small and, as already mentioned, are each provided with four digits. The hind-limbs are very strongly developed and each possesses five digits, the first three of which end in strong, black claws, which have caused the animal to be called the "Clawed Toad." Only the digits of the hind-limbs are webbed.

The skin is richly supplied with slime glands, and this slime has a strong musky smell, but is apparently not poisonous, since ducks are very fond of a Plathander meal. Besides these slime glands there are other "glands" of unknown function which have a very definite arrangement; they present the appearance of narrow pits about one-eighth of an inch long, and are situated in lines which are mostly coincident with the partitions between the subcutaneous lymph spaces.

The colour is yellowish white on the ventral surface, while the dorsal surface is brownish with darker, more or less circular patches. The colour varies considerably according to the intensity of light to which the animal is exposed, and in bright light the colour is very light. A greenish-blue colour can also be assumed, and I have found individuals of this colour in water with a large amount of algae, and also in a tank painted dark green on its inside.

The subcutaneous lymph spaces have a distribution somewhat differing from that of the frog; thus there is no saccus lateralis, the s. craniodorsalis and the s. abdominalis meeting laterally; also there is no septum between the saccus thoracicus and the s. abdominalis. Apart from those already mentioned there are, as in the frog, a saccus submaxillaris, s. brachio-radialis, s. femoralis, s. cruralis, s. supra femoralis, and s. intrafemoralis. The s. femoralis and s. supra-femoralis are only separated along the posterior edge of the leg.

Internal Anatomy.

The *alimentary canal* and its glands are similar to the same organs in the frog except that the liver, besides the right and left lobes, has a dorsal, transversely elongated lobe on the right side and a minute spherical fragment on the left side.

The lungs are much more highly developed than in the frog. In cross-section it shows a structure quite reptilian; in fact, it shows higher development than that of the koggelmannetje (Agama atra). There is a distinct longitudinal, central bronchus with numerous radial branches.

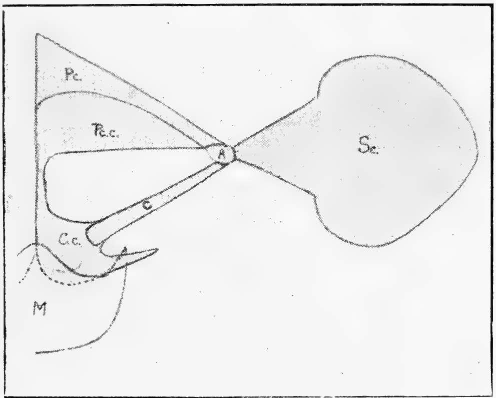


Fig 1.—The left half of the pectoral girdle, neutral view. Pc = clavicle (membrane bone); PcC = pre-coracoid cartilage; C = coracoid; Cc = coracoid cartilage; M = metasternum; Sc = scapula; A = glenoid cavity.

Skeleton.—With regard to the appendicular skeleton, the claws of the first three toes need mention; they represent the differentiated skin covering the terminal phalanges of the toes concerned.

Gadow contradicts the statement (which he says is occasionally made) that the pectoral girdle of the Aglossa is arciferous. For Xenopus, however, much could be said in favour of such a statement. Reference to the Fig. 1, which is not very diagrammatic although it may appear to be so, shows that the epicoracoid cartilages certainly forms an arch. Also there is an overlapping of epicoracoidal cartilage although this overlapping is not of the same sort as in typical arciferous girdles. The body of the metasternum (M) is ventral to the body of the coracoid cartilage (Cc), whereas the lateral horn of the former is dorsal to the lateral horn of the latter. The dorsal surface of the anterior edge of the metasternum has a pair of depressions into which the bi-lobed posterior end of the coracoid cartilage fits. We have thus a distinct overlapping of cartilages (coracoid and metasternum), and both these cartilages are epicoracoidal, since Gadow himself says that the sternal apparatus (consequently also the metasternum) of Anura belong, phylogenetically to the shoulder girdle and not to the ribs. We are thus entitled, I think, to call the pectoral girdle of *Xenopus laevis* arciferous.

The pelvic girdle is quite similar in shape to that of the frog, but the pubes are ossified. It differs from the frog as regards its attachment to the axial skeleton, for which see below. The inter-pubic cartilage is prolonged anteriorly into a long, ventral, lobed projection below the rectal region.

The Axial Skeleton.—There are, as in the frog, 9 vertebrae and a urostyle; they may be grouped as follows: 4 pectoral, 4 abdominal, 1 sacral. Of the pectoral group, the first is without ribs, while the succeeding three possess ribs fused with the diapophyses. The ribs of the third pectoral vertebra end in small plates of calcified cartilage; those of the fourth vertebra are longer and end in large flat plates also of calcified cartilage. The diapoplyses of the pectoral vertebra are stout and point backwards and outwards, while those of the abdominal group are thin, sharply pointed, and are directed forwards and outwards. The ninth vertebra or sacral is fused with the oss coccygium, but the strong, wing-like diapophyses belong to the ninth vertebra alone as is proved by the position of the exits of the ninth pair of nerves.

Gadow calls the vertebrae of the Aglossa epichordal and opisthocoelous. For *Xenopus laevis*, I add (1) neural spines insignificant and (2) the post-zygapophyses face downwards and slightly outwards to articulate with the prezygapophyses which face upwards and slightly inwards. The articulating surfaces of the zygapophyses are not plain; the post-zygapophysis is folded into two longitudinal ridges, fitting tightly into two corresponding, deep depressions on the prezygapophysis.

Iliac Articulation.—The anterior ends of the ilia lie along the ventral outer edges of the sacral diapophyses, and are firmly attached in that position. This is well known, but Gadow does not mention that the calcified end-plates of the ribs of the fourth pectoral vertebra curve backwards along the sides of the abdominal group and lie on the anterior, dorsal surfaces of the sacral diapophyses. These plates are more or less firmly kept in position on the sacrum by connective tissue and elastic fibres.

From the above it will be seen that the Plathander is extremely highly developed as far as bi-pedal locomotion is concerned. This sort of movement can be furthered in two very effective ways: (1) shortening of the pre-sacral vertebral column, and (2) increasing the rigidity of the column. The first is effected in Xenopus by extending the sacral vertebra forwards to the fourth pectoral (since this vertebra has also a share in iliac articulation) while the second is effected by the interlocking, longitudinal ridges and furrows on the zygapophyses. The fore-limbs, as mentioned above, are only used in feeding, and locomotion is entirely a function of the strong hind-limbs.

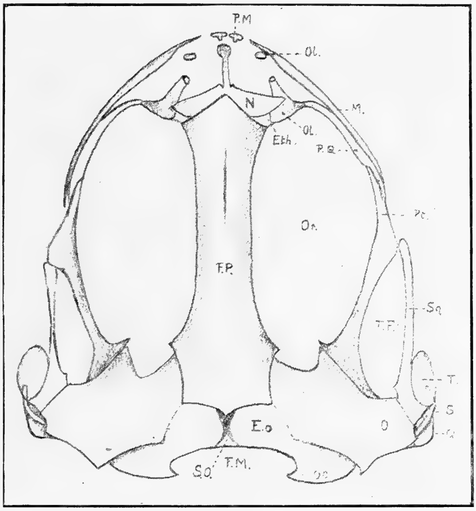


Fig. 2.—Dorsal view of skull. The nasals (N) lie dorsal to the fronto-parietals (FP).

The Skull (Figs. 2 and 3).—If the Plathander is left in boiling water for a few minutes, the skin and other soft tissues can readily be removed and the component bones of the skull disarticulated.

Roof of Cranium.—There is a very minute supraoccipital (SO) which remains cartilaginous; the frontals and parietals of both sides have fused and the two lateral fronto-parietals, so formed, have also fused along the median line (FP in Fig. 2). The Ethmoid region remains cartilaginous (Eth in Fig. 2).

Floor of Cranium.—In disarticulating the skull, one cannot separate the bones marked PS, OS, BS, and AS. Posterior to the bone BS there is a small cartilage which is not shown in the diagram; since the ex-occipitals meet underneath the hinder end of BS the latter must be a membrane bone; the small cartilage posterior to it must be the basi-occipital. BS, PS is then the para-sphenoid which is fused to the orbito-sphenoids (OS) and the ali-sphenoids (AS).

Sides of the Cranium.—There is, on either side, the following bones from behind forwards: (1) Ex-occipital (Eo), which is large and carries an occipital condyle (OC); (2) an ali-sphenoid which bridges the

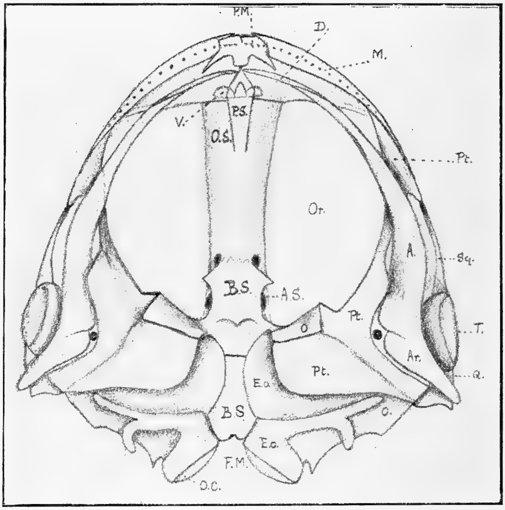


Fig. 3.—Ventral view of skull. For explanation of lettering of Figs. 2 and 3 see text.

space between the dorsal parietal and the ventral para-sphenoid and which is fused to the latter. It is, unlike that of the frog, completely ossified; (3) the orbito-sphenoid (OS) which bridges the space between the dorsal frontal and the ventral para-sphenoid; it is also ossified and is fused to the ali-sphenoid and, for a part of its length, to the para-sphenoid.

Sense Capsules.—The sclerotic of the eye is, of course, quite free from the cranium. The olfactory capsules are partly calcified (the two pairs of calcified cartilages marked Ol) and are protected by the dorsal nasals (Na) which are membrane bones. The auditory or otic capsules (O in Fig. 2) are fused to the ex-occipitals and are completely ossified. The quadrate (Q in Figs.) lies near the otic capsule on each side and helps to build up the auditory organ; it sends out processes which surround a cavity—the tympanic cavity—which is closed to the outside by a membrane—the tympanum (T in Figs. 2, 3). The columella, which is phylogenetically the hyomandibular bone and functionally a sound-wave conductor, abuts with one end on the tympanum whilst the other end it is fitted to the fenestra ovalis of the otic capsule.

Upper Jaw.—The primitive upper jaw is represented by the palato-quadrate cartilage (PQ in Fig. 2). In the Plathander, the palatal portion of the cartilage is complete, reaching to the ethmoid; also the quadrate portion is complete. The upper jaw is edged by the membrane bones, premaxilla and maxilla (PM and M in Fig. 3), and is articulated with the cranium through the pterygoid and the squamosal, both of which are developed as membrane bones on the quadrate, the former of the two ventral, the latter dorsal. The palato-quadrate cartilage branches into two, posteriorly; the lower branch meets the pterygoid to form the edge of the upper jaw while the dorsal branch meets the squamosal to form the temporal ridge. Teeth are borne on the premaxillae and on the maxillae.

Lower Jaw.—The lower jaw articulates with the quadrate, and each half of it consists of a dentary (D), an angular (A), and an articular (Ar). The angular and the articular are fused; the dentary is free. The lower jaw bears no teeth.

The Blood-vessels.

Arterial System (Fig. 4).—Gadow says: "The skin of the back and belly is supplied by two great branches of the arteria anonyma, one arising proximally, the other distally from the subclavian; herewith is correlated the almost complete absence of the arteria cutanea magna, which, as a branch of the pulmo-cutaneous, plays such a prominent rôle in the other Anura. Only in Pipa, but not in Xenopus, is the great cutaneous *vein* represented by a very small branch."

The word "vein" in the last sentence is obviously a typographical error, and should be artery, since this last sentence merely amplifies the preceding statement and since the cutaneous vein is very strong in Xenopus.

I find that the skin is supplied with blood by two large vessels, one from the subclavian and one from the sciatic, and also by numerous small ones from the brachial and the femoral; that the cutaneous branch of the pulmo-cutaneous is still present in Xenopus but that it is small (as reported for Pipa) and that it is given off from the pulmonary artery after the latter has entered the lung.

The carotid trunk, on each side, gives off (1) an artery (L) representing the lingual of the frog and distributed to the floor of the mouth; (2) a carotid (C) to the neck and head; (3) a muscularis (AM) to the ventral body-wall. This last artery should be noted, since it is not present in the frog whereas it is a large and important vessel in Xenopus.

The systemic trunk gives off (1) a mandibular (M) to the roof of the

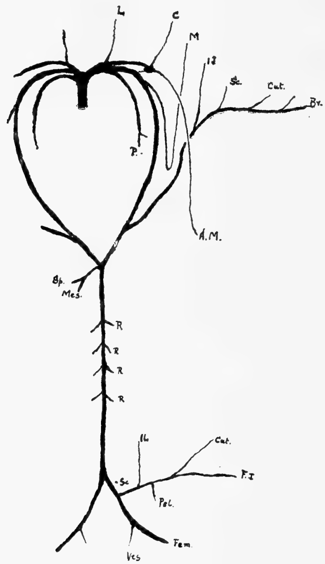


FIG. 4.—Diagram of arterial system. Carotid trunk: L = lingual; C = carotid artery; AM = muscularis. Systemic trunk: M = mandibular; IJ = internal jugular; Sc = scapular; Cut = cutaneous; Br = brachial; Sp = splenial; Mes = mesenteric; R = renal (1st pair also to reproductive organs); IL = iliac; Pel = pelvic; FI = artery to dorsal, anterior part of leg; Cut = cutaneous; Fem = femoral; Ves = vesicular; P = pulmonary.

mouth and the cranium; (2) an anonyma which branches into (*a*) an internal jugular (IJ) to the cranium; (*b*) a scapular (Sc) to the pectoral girdle; (*c*) a cutaneous (Cut), and (*d*) a brachial (Br). The brachial has a few small branches to the skin of the limb.

The pulmo-cutaneous trunk (P) has the usual pulmonary and cutaneous branches, but the latter, as already mentioned, is very small and leaves the pulmonary artery after the latter has entered the lung.

The dorsal aorta, at the point of its formation by the two systemic trunks and just between the two anterior ends of the kidneys, gives off an artery which at once branches into a splenic (Sp) and a mesenteric (Mes). Posterior to the above coeliac artery are given off the renal arteries (R) to the kidneys and three pairs of vertebral arteries to the dorsal body-wall. Underneath the bladder the dorsal aorta divides into right and left sciatics (Sc); each sciatic soon divides into two, one of which enters the leg as the principal artery of this limb after having given off a vesicular (Ves) branch to the cloaca, bladder, and rectum; this branch runs along the posterior, dorsal face of the hind limb and sends a number of small branches to the skin. The second branch of the sciatic breaks up into (*a*) an iliac (IL) to the muscles around the ileum, (*b*) a cutaneous (Cut) which is a fairly large artery to the skin at the side of the body just anterior to the limb, (*c*) an artery to the anterior, dorsal face of the hind-limb (labelled FI in Fig. 4), and (*d*) a small pelvic (Pel) to the posterior end of the pelvic girdle.

It will thus be seen that whereas the skin of the frog is supplied with impure blood from the cutaneous branch of the pulmo-cutaneous trunk, in Xenopus the skin is supplied with fairly pure (oxygenated) blood from the systemic trunk, through the subclavian and sciatic arteries. Also, the carotid trunk sends a large branch to the muscular ventral body-wall. An interpretation of all this may be found in the fact that the skin of the frog acts as a subsidiary respiratory organ, and therefore receives non-oxygenated blood, whilst Xenopus, owing perhaps to its life in deep and mostly bad water, possesses a skin which has no respiratory function and which consequently needs oxygenated blood. The cutaneous branch of the pulmo-cutaneous of the Plathander is therefore on its way to becoming vestigeal and is already almost wholly replaced by branches of the subclavian and sciatic arteries. The muscularis of the carotid may also have been developed in connection with the degeneration of the cutanea magna.

The Venous System (Fig. 5).—The three caval veins (two prae-cavals and a post-caval) and the pulmonary veins are similar to those of the frog. The external jugulars (EJ) are, however, very variable, since I have found specimens with only the right external jugular, others with only the left, still others with both normal, and finally some with the right and left joined between the thymus glands as in Fig 5. The skin is mostly drained by the cutaneous branch of the innominate vein, but the iliac, the femoral, and the brachial also receive branches from the skin. The renal portal system is very complicated. The femoral, which is the principal vein of the leg, is joined on the one hand to the renal portal vein (RP) and on the other to the abdominal (Abd) by means of a short thick pelvic (Pelv); the pelvic receives cloacal (Clo), cutaneous (Cut),

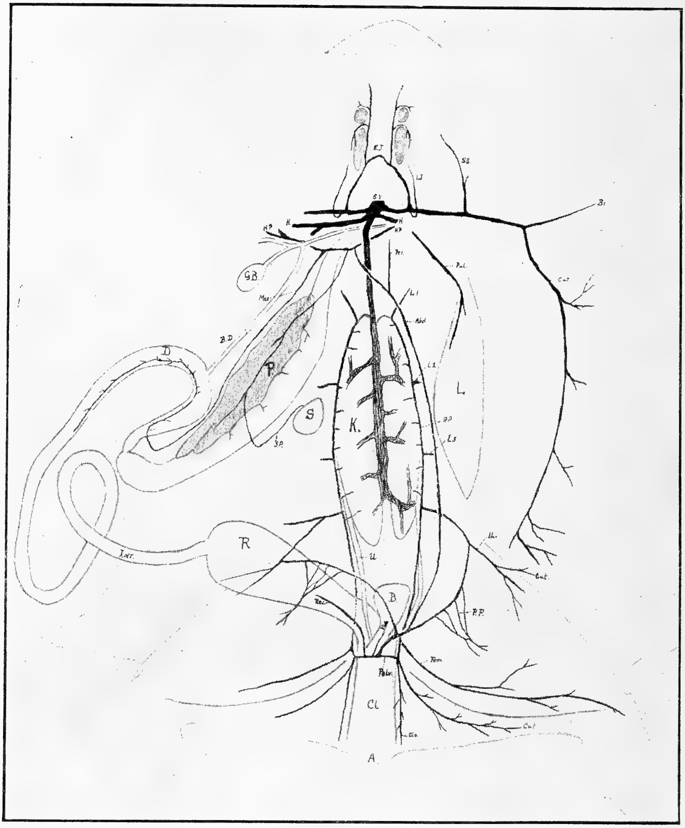


Fig. 5.—Venous system. The heart is removed and the sinus venosus (SV) and two precavals are drawn comparatively narrow to give greater clearness. The three lobes of the liver are removed. EJ = external jugular; IJ = internal jugular; SS vein from pectoral girdle (ventral and dorsal branches); Br = brachial; Cut = cutaneous; Pul = pulmonary; H = hepatic; H.P = hepatic portal; Mes = mesenteric (from Duodenum D); SP = spenial (from spleen S and pancreas P); Abd = abdominal; Per = pericardial; L1,L2,L3 = dorso-lumbars into renal portal RP; the two RP veins joined across cloaca (Cl) by pelvic (Pelv) which receives the vesicular (Ves) from bladder (B), rectal (Rec) from rectum (R), cloacal (Clo) and cutaneous (Cut). Two iliacs (IL) open into the RP veins and two femorals (Fem) into the abdominal. The iliac and femoral of each side is connected by a ventral vein into which flow the plexus (PP).

vesicular (from bladder), and rectal (Rec) branches. The sciatic (also called iliac), which is the vein from the dorsal part of the femur, receives a cutaneous branch and is connected to the renal portal vein on the one hand and on the other to the abdominal by means of a long vein which I shall call "pubic"; the pubic vein receives blood from a "pubic" plexus (PP).

In the frog the blood from the iliac (or sciatic) veins must pass through the kidneys; in Xenopus the blood from the whole of the posterior part of the animal may take two courses, either through the kidneys or through the abdominal vein to the liver.

There are three lumbar veins (L 1, 2, and 3) opening into each renal portal, and the latter also receives the blood from the oviduct or vas deferens. The anterior pair of lumbars (L 1) are long and drain the diaphragm muscles which attach the oesophagus and lungs to the anterior ends of the ilia. The ovaries and testes are drained by veins from the post-caval.

The abdominal vein receives minute branches along its course under the skin and also a large branch (Per) from the body-wall over the heart. Anteriorly the abdominal, as usual, opens into the hepatic portal system.

The hepatic portal system (HP) consists of (1) a vessel from the pancreas with a branch from the spleen, and (2) a vein from the duodenum; it opens into the liver by means of three branches. From the liver the blood is taken to the heart through the hepatic veins (H).

The venous system of the Plathander is thus only different from that of the frog (as described in Parker and Parker) in that the iliac veins are joined to the abdominal vein by the long "pubic" veins and that the pelvic veins are very short, being situated transversely across the end of the rectum. The "pubic" plexus is situated on the ventral face of the thigh; the "pubic" veins join the abdominal at the ventral point of the pubic symphysis and the pelvic veins join the abdominal at the dorsal point of the symphysis.

The Nervous System.

The brain and cranial nerves are similar to those of the frog, and so need no special mention. The spinal nerves differ in that the seventh spinal nerve is not joined to the eighth in order to form the sciatic plexus; also the tenth spinal nerve is absent. The sympathetic system (Fig. 6) is slightly different to that of the frog. There are, on each side, six ganglionic swellings and the chord is joined to all the spinal nerves and to the vagus. The seventh spinal has a double connection with the sympathetic chord and the chord, ends on the ninth spinal nerve as a broad flat swelling. There are three sympathetic nerves: one (CP) runs along the mandibular artery and no doubt goes to the cardiac plexus; a second (SP) runs down into the mesentery and is probably connected to the solar plexus; a third (MP) runs upwards to the tissues along the vertrebal column just beneath the kidneys and is possibly connected to the renal-reproductive plexus. Besides these sympathetic nerves there is a ring (R) which encircles the innominate artery without giving off any branches.

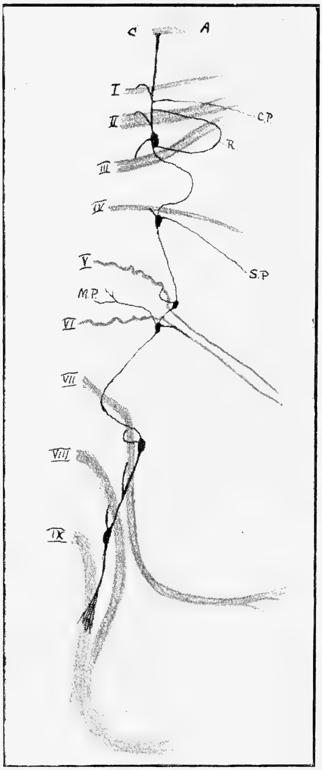


Fig. 6.—The Sympathetic system. I—IX = the spinal nerves; A = Vagus (cranial nerve); CP = sympathetic curve to cardiac plexus; R = loop (with no nerves of sympathetic chord; SP = sympathetic nerve to solar plexus; MP = symph. nerve to renogenital plexus (?).

Random Observations on Xenopus Tadpoles. The very young tadpoles are very much like those of frogs; the colour is of the usual muddy, somewhat opaque grey and the tail is without the "fins." They can, however, be distinguished by the fact that the jaws are not horny; there are no tentacles. Later on as the young tadpole grows, its skin becomes clearer and finally quite transparent; the head becomes flattened and the sides of the mouth grow forwards; the tentacles are developed on the protuberances at the sides of the mouth. The tail is well developed and its point, unlike that of other tadpoles with which I am acquainted, performs continuous vibratory movements which have nothing to do with locomotion.

I have not been able to get Xenopus to deposit eggs in the laboratory, but I have managed to net very small larvæ and have seen no trace of external gills. There is a delicate operculum which opens to the exterior by two lateral openings. The operculum never covers the fore-limbs as in the frog; these limbs are seen as minute, white, opaque knobs at a very early stage in the development.

The pharynx (Fig. 7) is more or less triangular in outline when looked at from above or below; the one point is anterior the other two postero-lateral. The whole cavity of the pharynx is continuous; the gill-slits are really gill-*pouches* in the floor of the pharynx; these "pouches" are long narrow grooves of which there are three pairs, the anterior pair being the longest, the posterior pair the shortest. The grooves are supported by bars of cartilage lying between them and sending branches to their ventral floors. The lumen of each groove is much reduced by a fold of skin from the roof of the pharynx which grows down and causes

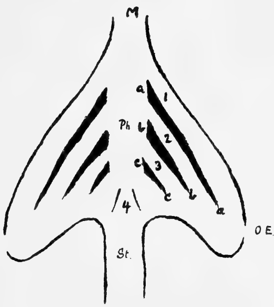


Fig. 7.—Schematic dorsal view of pharynx (from reconstruction of serial sections). M = mouth cavity; St = stomach; Ph = central canal of pharynx; 1, 2, 3 = grooves in floor of pharynx separated from each other by ridges a, b, c, 4 = opening of lungs. OE = opening to exterior (see text).

the gill-grooves to be **V**-shaped in section. Posteriorly thei three pairs of grooves open into a common chamber, which in turn communicates with the exterior.

The membranous labyrinth of smaller tadpoles (toes of foot already separately seen by naked eye as little knobs), I have carefully reconstructed from serial sections. The sacculus has the cochlea well developed and has the usual macula sacculi, m. lagenae and papilla acustica; besides the papilla acustica the m. lagenae is further, more or less, separated into two maculae. The utriculus and the three semicircular canals with the three cristae staticae, the macula acustica utriculi and the macula neglecta are also usual. The ductus endolymphaticus enters the cranium and swells into a large vesicle lying latero-dorsal to the brain, and containing an opaque limey fluid.

In young tadpoles with the hind-limbs just beginning to show there is already a high degree of differentiation of the olfactory capsules (Fig. 8). There is an almost straight wide tube leading from the external nares (E) to the mouth cavity (M); into this the two chambers of the capsule open and the posterior end of the *anterior* chamber (AC) opens into Jacobsohn's organ, which in turn communicates with the mouth (MI).

The Xenopus tadpoles, as already remarked, have no horny jaws and

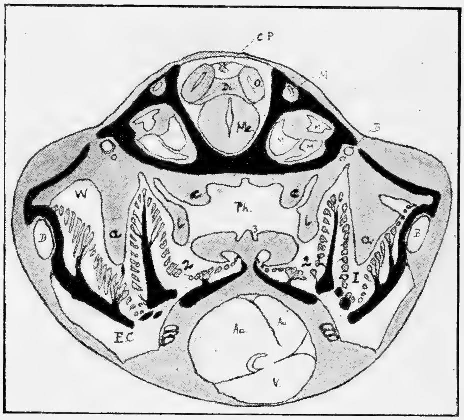


FIG. 8.—Cross-section in region of heart (Au = auricle, V = vertricle) to show the grooves 1, 2 and 3 and ridges a, b and c of the pharynx. The groove 3 is short and the section passes through its anterior end. Notice that both grooves 1 and 2 open into the opercular cavity EC; these openings are irregular and situated at the posterior ends of the grooves. W is a portion of the groove 1, which passes backwards beyond the external opening (OE in Fig. 7) and is filled with foodstuff kept back by the sieve-like respiratory tissue. Each **V**-shaped groove contains two cavities—the intra-pharyngeal (*e.g.* W) and an extra-pharyngeal situated below the "sieve"; the latter is supported by irregularly arranged bars of cartilage. M = portions of membranous labyrinth; Me = medulla oblongata; Di = diencephalon; O = optic lobi; CP = choroid plexus; B = blood-vessel.

their method of feeding is therefore different to that of frog tadpoles. Instead of browsing on algal filaments they hover near the bottom of the vessel containing them, their mouths being near the bottom and the tails pointing obliquely upwards. In this position they perform continuous, rhythmic swallowing movements, and so ingest the minute protozoa and algæ living on the bottom. It seems that they need principally an animal diet, since a few placed in a large vessel with a mass of algæ floating on the water, made no appreciable growth during a period of about 2½ months and finally died before completing their metamorphoses.

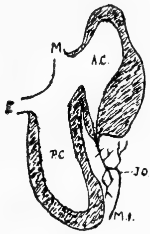


Fig. 9.—Diagrammatic representation of olfactory organ. E = external opening; M and MI = openings into mouth. AC = anterior chamber; PC = posterior chamber; JO = Jacobsohn's organ.

They had sufficient plant food, for the water must have swarmed with algal spores, and they also passed large quantities of faeces—yet they remained approximately the same size for over two months and then died.

ON VARIATIONS IN THE MAGNETIC DECLINATION AT BLOEMFONTEIN.

By W. A. Douglas Rudge, M.A.

(Received April 8, 1913.)

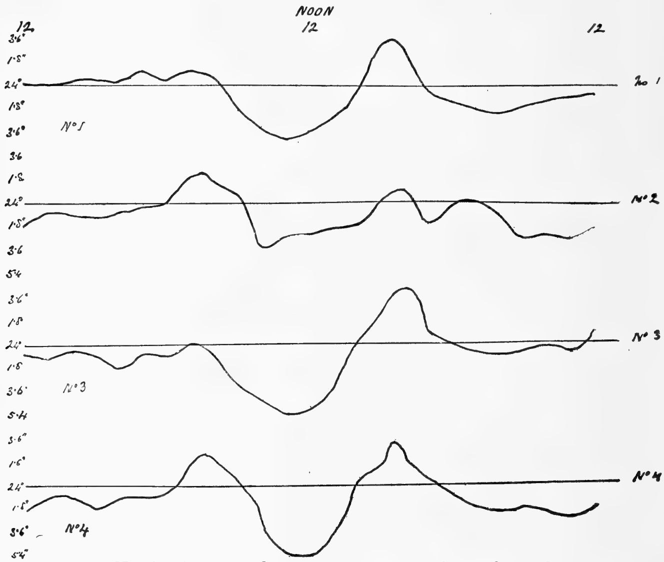
Some magnetic observations have been taken at Bloemfontein during the past year, and although they are not very complete they may be of interest because, so far as I know, regular observations have not been taken of late years in South Africa. The observations were taken in a small house specially built for the purpose in the grounds of the Grey University College. All the materials used were non-magnetic and the instruments were firmly mounted on brick and concrete pillars.* The instrument employed was a Kew magnetometer, supplied by the Cambridge Instrument Company and tested at Kew. Time did not permit of absolute values being determined, and the present note will just serve to give the times of the daily maxima and minima for a period of two selected months, together with twelve complete daily records of observations taken at intervals of about two weeks. The observations lasted from August to December.

The magnetic house was erected with the walls approximately oriented, with windows facing north and south, but the actual direction of the meridian was determined from the stars, by the aid of a small theodolite. This was done by clamping the telescope of the instrument at a convenient angle, so that the image of a bright star could be brought in contact with the point of intersection of the cross-wires. The azimuth reading was then taken. The time of this observation was about an hour before the time of "southing" of the star, and a second one, when, after rotating the telescope about the vertical axis, the image of the star again coincided with the centre of the cross-wires. A second azimuth reading was then taken. Since the altitude of the star was the same at the two observations, the meridian could be found by bisecting the angle made by the two azimuth readings. The telescope was then released and brought to a horizontal position, with its axis bisecting the two azimuth directions obtained. A pair of posts with

* Brickwork may be magnetic.

pointed steel rods at the top were then fixed one behind the other, by bringing the images in coincidence with the cross-wires. The position of the magnetometer was then so adjusted that the straight line joining these two rods when produced passed through the centre of suspension of the magnet.

The magnet's suspension consisted of several strands of unspun silk fibre, and the magnet was not removed during the period over which

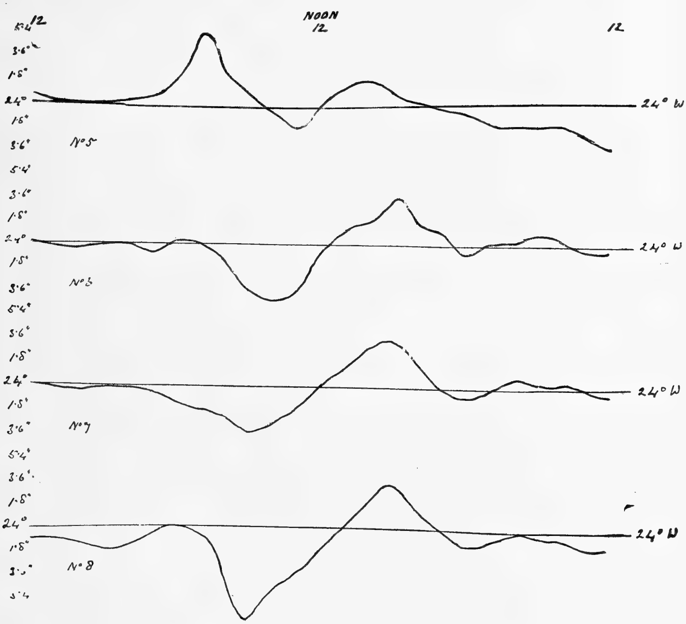


No. 1. August 15th. No. 3. September 2nd.
No. 2. August 22nd. No. 4. September 13th.

the observations were taken. The effect of any change in the torsional zero was probably negligible and could not have affected the value of the declination in the most extreme cases by more than a few seconds.

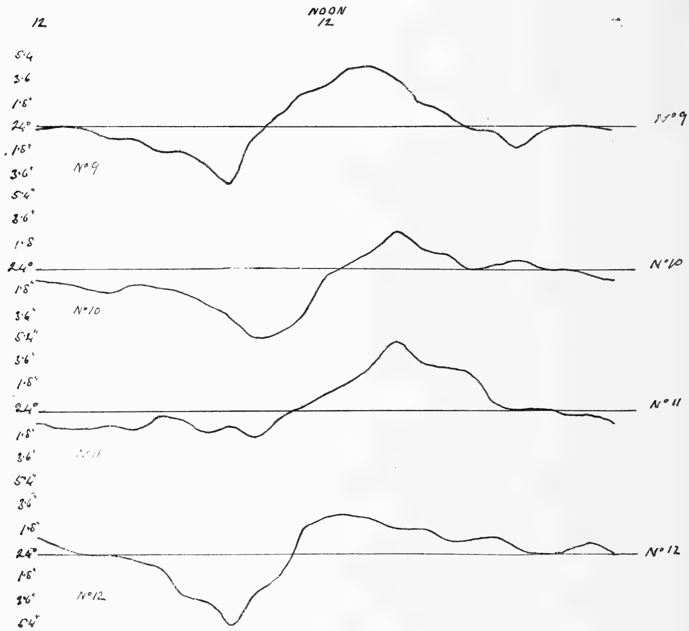
As the observations were "eye" ones the exact time, and also the magnitude of the maximum or minimum values, can only be deduced by interpolation, so that those given in the table are approximate. The declination was found to be very near to 24° W., but of course it varied during the day, the variation amounting to a few minutes. The observations were taken as frequently as possible between the hours of 6 a.m. and midnight, and at intervals of about two weeks a complete day's record of hourly observations was secured.

Table I. shows the time of the two maxima and minima for each day in September and October, whilst Table II. gives the complete daily records from midnight to midnight in divisions of the scale for selected



No. 5. September 25th,
No. 6. October 7th.
No. 7. October 20th.
No. 8. October 31st.

days. The readings were taken with the magnet swinging slightly, and the scale in the magnet could easily be read to $\frac{1}{10}$th of a division. The value of each division was stated on the Kew certificate to be 1·8′. The extreme range of the variation on any day did not exceed 10·8′ for the maximum and 2·6′ for the minimum. The first diurnal minimum to the east occurred at about 7 a.m. and the second somewhere between 2 and and 3.30 p.m., but many divergencies may be noted. The curves drawn from the twelve complete days' work are seen to be fairly regular and indicate that the daily range is not very constant, a notable deviation occurring on September 25th. The horizontal line drawn through the various curves corresponds to a declination of 24° W. Distances above the line show the easterly variation. The points 1·8′, etc., above and below the line give the value in minutes of 1, 2, 3 divisions of the scale.



No. 9. November 3rd. No. 11. December 3rd.
No. 10. November 17th. No. 12. December 8th.

For any adequate discussion of the magnetic variation at any plane at least one year's complete records are necessary, for the times at which the variation changes from the extreme eastward or westward position alters with the time of the year. In the curves given the whole period extends only over one-third of the year, and the tendency appeared to be directed to putting the time of the first max.—*i.e.*, the extreme westerly position earlier in the day. From August 11th to November 18th the time changed from 1.30 p.m. to 7 a.m., not very regularly, it is true, and from November 18th to December 17th the time changed to about 8.30 a.m.

It has, of course, been known for a long time that there was a change in the time of the first Easterly maximum, between the months of September and October, which seems to depend upon the position of the sun. This was shown by General Sabine more than sixty years ago, from a study of the records taken at Cape Town and St. Helena. These records ceased, I think, in 1851. My curves from September 25th and October 7th show a very marked difference in the magnitudes of the first maxima very similar to that shown in the curves drawn by General Sabine.

It is much to be desired that a permanent Magnetic Observatory with self-recording instruments should be established in South Africa, as there are many problems to be solved in connection with terrestrial magnetism.

The observations given above were taken as carefully as possible under the conditions of working, but for work of this description the undivided attention of the observer is necessary, and cannot be adequately done during the spare time at the disposal of one engaged in teaching work. Professor Beattie has carried on a very valuable series of magnetic observations in South Africa, and it was a study of his work which induced me to endeavour to add a small quota to the knowledge of the variation of the declination.

TABLE I.

Showing the Daily Range of the Declination in Minutes of Arc, and the Times of the Maximum and Minimum Variation from 24° W.

Date.	Range in Minutes.	First Min.	Second Min.	First Max.	Second Max.
		a.m.	p.m.	a.m.	p.m.
Sept. 1	5·94	7.0	3.0	11.15	6.0
2	9·3	6.40	4.10	11.20	8.30
3	3·6	6.30	5.0	10.50	7.10
4	8·6	7.30	4.20	11.40	8.0
5	4·7	6.50	4.0	11.10	8.0
6	7·2	8.0	4.30	10.30	6.0
7	8·64	7.10	3.10	10.45	6.20
8	7·22	7.10	—	11.0	6.50
9	5 94	7.0	3.30	11.30	7.15
10	6·84	6.45	3.45	11.40	7.50
11	7·38	7.0	3.30	11.0	7.0
12	7·36	6.45	4.30	12.0	10.10
13	6·9	7.20	3.35	12.0	10.40
14	7·92	7.30	4.0	11.20	6.0
15	7·84	7.0	3.15	11.45	7.20
16	9·0	6.50	3.10	11.0	6.30
17	9·9	6.45	3.45	11.0	9.40
18	3·96	7.0	3.50	11.15	10.15
19	5·7	6.30	5.0	15.0	11.40
20	7·95	6.50	4.30	11.5	8.0
21	5·76	7.0	3.20	11.0	8.0
22	6·48	6.45	3.30	11.20	9.30
23	3·6	7.0	3.0	10.30	7.30
24	8·7	7.0	2.5	11.0	12.0
25	2·7	6.30	2.0	9.0	7.0
26	8·1	6.45	2.50	10.15	6.40
27	3·24	6.40	3.0	8.30	6.0
28	5·6	6.0	3.20	9.0	7.30
29	7·4	6.30	2.45	9.15	6.0
30	8·5	6.45	2.10	10.0	6.0
Oct. 1	7·92	7.0	1.50	9.0	7.45
2	7·2	6.30	2.30	10.0	6.30
3	7·74	6.50	2.20	9.20	7.30
4	4·64	6.30	2.30	9.0	8.0
5	3·96	6.20	2.15	8.30	7.0
6	10·26	5.45	2.30	11.10	7.15
7	7·2	6.30	3.0	10.40	6.30
8	8·7	—	2.0	9.0	7.0
9	7·45	6.0	2.45	9.20	7.40
10	5·66	5.50	3.0	9.10	9.5
11	6·46	5.45	2.30	10·20	10.30
12	8·28	6.10	2.15	10.0	8.30
13	7·15	—	2.15	9.0	5.30
14	10·0	5.30	2.30	8.30	8.0
15	8·1	6.50	1.30	8.30	5.45
16	3·75	5.0	2.30	6.50	7.30
17	—	—	—	—	—
18	6·3	6.15	2.30	8.0	8.30
19	8·1	6.50	2.30	8.50	8.0
20	7·2	5.45	2.40	9.15	6.30
21	10·26	6.0	3.15	8.30	7.30
22	9·9	6.40	1.30	8.45	7.0
23	8·4	6.50	12.0	8.20	8.30
24	7·0	6.30	1.30	7.50	5.30
25	10·8	6.20	1.45	9.0	5.40
26	9·72	—	1.0	8.40	5.0
27	10·8	6.15	2.45	10.30	6.0
28	7·2	6.20	3.0	8.50	6.30
29	10·2	6.50	2.30	9.30	8.0
30	9·9	6.30	2.45	9.15	9.0
31	10·6	6.50	2.20	9.0	6.0

The range is given in minutes of arc.

TABLE II.

Complete Daily Records from which the Curves were Drawn. The 40th Division of the Scale corresponded very nearly to a Declination of 24° West. 1·8′ corresponded to One Scale Division.

Time.	Aug. 15.	Aug. 21.	Sept. 2.	Sept. 12.	Sept. 25.	Oct. 7.	Oct. 20.	Oct. 31.	Nov. 3.	Nov. 17.	Dec. 3.	Dec. 8.
12	42·0	41·0	41·6	41·0	42·3	42·0	*42·0	41·5	41·9	41·6	41·5	*42·7
1 a.m.	42·0	41·6	41·4	41·8	42·0	41·9	41·9	41·5	*42·0	41·4	41·3	42·3
2	42·1	41·5	41·7	41·5	42·0	41·8	41·8	41·3	41·9	41·2	41·3	42·0
3	42·2	41·4	41·5	41·0	42·0	41·9	41·9	41·0	41·7	41·0	41·4	42·0
4	42·2	41·6	41·6	41·4	42·2	42·0	41·9	41·2	41·5	41·4	41·2	41·8
5	*42·6	41·8	41·6	41·4	42·3	41·6	41·7	41·6	41·0	41·2	*41·8	41·5
6	42·1	42·0	41·5	41·8	43·3	*42·2	41·3	*42·0	41·0	41·0	41·6	40·3
7	42·5	43·0	*42·0	*43·0	*45·0	42·0	41·0	41·6	40·5	40·5	41·0	40·0
8	42·3	*43·3	41·5	43·0	43·4	41·3	40·7	40·0	*39·5	40·0	41·4	*39·0
9	40·9	42·9	40·2	42·1	42·5	40·0	*40·0	*38·0	41·4	*39·0	*40·8	40·3
10	40·2	*40·1	39·6	40·0	41·8	*39·6	40·5	39·2	42·4	39·3	41·7	41·0
11	*39·7	40·6	*39·0	39·1	*41·0	40·0	41·0	39·9	43·3	40·0	42·2	43·0
12	40·0	40·7	39·3	*39·0	42·0	41·7	42·0	41·0	43·7	41·6	42·7	43·5
1 p.m.	40·6	40·9	40·1	40·2	42·7	42·5	42·7	42·0	44·4	42·2	43·2	*43·6
2	41·6	41·0	42·0	42·3	*43·0	42·9	43·7	43·0	*44·5	42·9	44·0	43·4
3	43·6	42·0	43·3	43·0	42·5	*43·5	*44·0	*43·9	44·0	*43·6	*45·0	43·0
4	*43·6	*42·5	*44·3	*43·0	42·1	42·9	43·1	42·8	43·0	42·9	44·0	43·0
5	41·8	41·0	42·5	42·2	41·8	42·5	42·0	42·0	42·6	42·6	43·8	42·5
6	41·3	41·8	42·0	41·6	41·6	41·5	*41·6	*41·3	42·0	42·0	43·6	42·6
7	41·0	42·0	41·6	41·0	41·2	42·0	42·0	41·5	41·8	42·1	42·3	42·7
8	*41·0	41·5	*41·5	41·0	41·1	42·1	42·4	41·9	*41·0	42-3	42·0	42·2
9	41·0	*40·5	41·6	41·0	41·0	42·4	42·2	41·8	41·7	42·0	42·0	*42·0
10	41·3	40·6	41·8	40·8	41·0	42·2	42·2	41·7	42·0	41·9	41·8	42·1
11	41·4	40·5	41·7	*40.6	40·5	41·8	42·0	41·3	42·0	41·7	41·8	42·5
12	41·6	40·9	42·5	41·0	*40·0	*48·8	41·7	41·3	41·8	*41·5	*41·5	42·0

The time of maximum easterly and of maximum westerly variation are indicated by the asterisked numbers. The afternoon westerly minimum indicated by the highest reading of the scale is the most regular.

NOTE ON THE VERTEBRAL COLUMN OF THE BUSHMAN RACE OF SOUTH AFRICA.

By R. B. Thomson, M.B., F.R.S.E., *South African College.*

(Received and Read May 21, 1913.)

The study of the relative position of man in nature, and of the different races of mankind to each other according to their bodily structure, civilization, and culture, is one in common with all other sciences, which call for further investigation and accumulation of data. Especially is this true of those races which are believed to occupy a low morphological position, such as the Bushman race of South Africa.

During last year, 1913, Miss Winifred Tucker, B.A., in course of an anthropological survey in the Richtersveld procured three skeletons, and kindly presented these to the Anatomical Department of the South African College, forming the nucleus of an osteological museum.

Two of the skeletons (numbered S.A.C. 1 female, and S.A.C. 2 male), are almost complete and in excellent preservation. They are traditionally Bushman skeletons, and were found curled round with the hands lying close to the chin, and with the knees drawn up; otherwise there was no special orientation to be observed in the mode of burial. From all the indications, Miss Tucker was of opinion that they were Hottentot graves, but as the Hottentots still bury their dead in the outright position, they were quite indignant when asked if they knew of no other way.

The third skeleton (numbered S.A.C. 3 male) was found exposed near the mouth of the Orange River. The bones are consequently bleached and fragile, a few of the bones having partly crumbled away.

The researches of Mr. Shrubsall* have clearly shown that the Bushman race of South Africa could be divided into two distinct classes—the Strandlooper and Inland Bushman, the Strandlooper being a more homogeneous group than the Inland Bushman, which would appear to be

* Shrubsall, "Annals of South African Museum," vol. 5.

intermediate between the Strandlooper and the Hottentot. In order to satisfy myself regarding the three skeletons under observation, I have made careful investigation of them, and have found that according to Shrubsall's methods and tables they would appear to fall into the intermediate group between the Strandloopers and Hottentots, and to which Cunningham* has given the name of Hottentot-Bushmen.

Few regions, indeed, of the skeletons of the South African Bushman have failed to give evidence of distinct racial character; thus the crania with regard to their capacities and indices have been carefully examined by many observers and found to present characteristic racial structure. The same holds good of the vertebral column, especially in its lumbar and sacral regions, as well as many of the bones of the upper and lower limbs.

In this paper it is proposed to deal with the vertebral column, and although the number of specimens is small, still, certain points in the cervical and thoracic regions appear to be possibly of some importance for verification by examination of further material. With regard to the lumbar and sacral regions, the results help to swell the necessary data for a satisfactory definite classification. For purposes of comparison I have examined the vertebral column in three European skeletons, the various measurements and indices being compared with one another.

Cervical Region. Vertebrae Cervicales.

The centrum and vertebral foramen each lend themselves to measurement, and the following indices have been constructed.

Corpus.—The antero-posterior length is taken through the centrum from front to back at points equidistant from the upper and lower borders: the breadth or transverse diameter—from the central point between the anterior and posterior roots of the processus transversus medial to the foramen transversarium on the caudal aspect of the bone, the callipers being most conveniently adjusted at this point; the depth—from the centres of the corpus on the cranial and caudal surfaces.

$$\text{Length-Breadth Index} = \frac{\text{Length} \times 100}{\text{Breadth}}.$$

$$\text{Length-Depth Index} = \frac{\text{Depth} \times 100}{\text{Length}}.$$

Foramen Vertebrale.—The antero-posterior length is measured from the upper border of the posterior surface of the corpus to the centre of the

* Cunningham, "Memoirs II."

upper edge of the arcus vertebrale opposite; the breadth—between the medial aspects of the pedicles (radix arcus vertebrae).

$$\text{Length-Breadth Index} = \frac{\text{Length} \times 100}{\text{Breadth}}.$$

European. Cervical Vertebrae. Corpus.

No. of Vertebra.	No. 1.			No. 2.			No. 3.		
	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.
2	14	29	35	14	24	31	13	25	33
3	16·5	26	12	13	21·5	10	16	24	11
4	16	25	11	12	22	11	14	26	10
5	15·5	29	11	14	26·5	10	17	26	11
6	18	32	11	16	28	12	16	27	10
7	19	35	12	14	29	10	15	30	11
Total	99	176	92	83	151	84	91	158	86
	Length-Breadth Index, 56·3 Length-Depth Index, 92·9			Length-Breadth Index, 54·9 Length-Depth Index, 100·2			Length-Breadth Index, 57 6 Length-Depth Index, 94·5		

Average Length-Breadth Index, 56·26.
Average Length-Depth Index, 95·8.

Bushman. Cervical Vertebrae. Corpus.

No. of Vertebra.	No. 1.			No.			No. 3.		
	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.
2	10	24	29	11	21	25	13	24	30
3	12	21	8	12·5	18	7	—	—	—
4	11	22	9	12	20	8·5	—	—	—
5	11	22	8·5	11	21	8·5	—	—	—
6	12	24	8·5	12	24	9	—	—	—
7	12	26	9	12	26	9·5	16	28	11
Total	68	139	72	70·5	130	67·5	—	—	—
	Length Breadth Index, 48·9 Length-Depth Index, 105·8			Length-Breadth Index, 54·2 Length-Depth Index, 95·7					

Average Length-Breadth Index, 51·5.
Average Length-Depth Index, 100·7.

European. Cervical Vertebrae. Vertebral Foramen.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Length.	Breadth.	Length.	Breadth.	Length.	Breadth.
1	19	29	21	28	21	29
2	17·5	22	18	24	20	24
3	15	20	14	24	15	23
4	15	23	15	25	14	24
5	14·5	25	13	25	15	24
6	14	24	13	27	15	25
7	15	24	14	26	15	25
Total ..	110	167	108	179	115	174
	Length-Breadth Index, 65·8		Length-Breadth Index, 60·3		Length-Breadth Index, 66	

Average Length-Breadth Index, 64·03.

Bushman. Cervical Vertebrae. Vertebral Foramen.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Length.	Breadth.	Length.	Breadth.	Length.	Breadth.
1	20	25	20	26	—	—
2	19	22	17	21	—	—
3	14	21	15	21	—	—
4	13	21	15	22	—	—
5	14	22	15	22	—	—
6	13	22	14	22	—	—
7	13	21	13	21	—	—
Total ..	106	154	109	155	Bones Defective	
	Length-Breadth Index, 68·8		Length-Breadth Index, 70·3			

Average Length-Breadth Index, 69·5.

A comparison of these indices would appear to show that in the Bushman the bodies of the vertebrae were relatively narrower in their antero-posterior length and deeper in their vertical depth than in the European by about 5 per cent. in each case. The vertebral foramen is relatively longer in the Bushman, thus corresponding with the length-breadth index of the skull, which gives an indication of the relative dimensions of the cranial cavity.

Of the other parts of the Bushman cervical vertebrae the non-bifid and less obliquely inclined spinous processes are distinctive, while the interlocking arrangement of the bodies appears to be somewhat poorly developed as compared with those of the European.

Thoracic Region. Vertebrae Thoracales.

The antero-posterior diameter (length), transverse diameter (breadth), and vertical depth of the bodies are taken at the centres of the bodies from front to back, from side to side, and from above to below respectively. The vertebral foramen is measured as in the cervical vertebrae, and the indices are similarly arranged.

EUROPEAN. THORACIC VERTEBRAE. CORPUS.

No. of Vertebra.	No. 1.			No. 2.			No. 3.		
	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.
1	18	28	15	15	28	12	16	29	15
2	19	26	15	17	26	13	17	28	16
3	20	23	17	20	23	14	19	26	17
4	22	23	18	21	22	15	21	24	18
5	23	25	18	22	22	15	22	25	19
6	26	26	18	23	24	16	24	27	20
7	29	28	19	24	25	16	26	28	21
8	31	30	18	25	27	17	29	29	21
9	31	31	19	26	28	18	30	31	21
10	30	32	20	26	29	18	29	31	22
11	30	35	21	26	31	18	28	35	22
12	30	38	23	27	32	20	30	38	25
Total	309	345	221	272	317	192	291	351	237
	Length-Breadth Index, 89·5 Length-Depth Index, 71·2			Length-Breadth Index, 85·8 Length-Depth Index, 70·5			Length-Breadth Index, 82·9 Length-Depth Index, 81·4		

Average Length-Breadth Index, 86·06.
Average Length-Depth Index, 74·3.

BUSHMAN. THORACIC VERTEBRAE. CORPUS.

No. of Vertebra.	No. 1.			No. 2.			No. 3.		
	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.
1	13	24	12	14	24	11	—	—	—
2	14	25	12	15	24	11	—	—	—
3	15	22	12·5	16	22	12	—	—	—
4	16	21	13	17	21	13	—	—	—
5	18	20	14	17	20	14	—	—	—
6	19	20	15	18	21	14	—	—	—
7	20	21	15	20	22	14	—	—	—
8	21	20·5	15	21	22	15	—	—	—
9	21	21·5	15·5	21	23	15	—	—	—
10	22	22	16	21	24	15	26	28	18
11	22	24	17	22	25	15	25	35	20
12	21	25	18	21	27	16	25	37	21
Total	222	266	175	223	275	165	—	—	—
	Length-Breadth Index, 83·4 Length-Depth Index, 78·8			Length-Breadth Index, 80·1 Length-Depth Index, 74					

Average Length-Breadth Index, 81·7.
Average Length-Depth Index, 76·4.

European. Thoracic Vertebrae. Vertebral Foramen.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Length.	Breadth.	Length.	Breadth.	Length.	Breadth.
1	15	20	14	21	16	23
2	16	18	14	18	16	19
3	16	17	15	15	16	17
4	17	17	15	15	17	17
5	17	17	15	15	17	17
6	16	17	15	15	16	17
7	16	17	15	15	16	17
8	16	17	15	16	16	17
9	16	18	14	17	16	18
10	16	18	14	17	16	18
11	17	19	15	18	16	17
12	16	22	16	21	16	19
Total ..	194	217	177	203	194	216
	Length-Breadth Index, 89·4		Length-Breadth Index, 87·1		Length-Breadth Index, 89·8	

Average Length-Breadth Index, 88·7.

Bushman. Thoracic Vertebrae. Vertebral Canal.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Length.	Breadth.	Length.	Breadth.	Length.	Breadth.
1	13	18	13	13	—	—
2	14	16	14	17	—	—
3	14	16	14	15	—	—
4	14	16	14	14	—	—
5	14	15	14	15	—	—
6	14	15	14	15	—	—
7	14	15	14	15	—	—
8	15	16	15	15	—	—
9	15	17	15	15	—	—
10	15	17	15	16	—	—
11	15	18	15	16	—	—
12	15	19	16	18	—	—
Total ..	172	198	173	189	—	—
	Length-Breadth Index, 86·8		Length-Breadth Index, 91·5			

Average Length-Breadth Index, 89·1.

The indices show that, as in the cervical vertebrae, the bodies of the thoracic vertebrae are relatively shorter and deeper in the Bushman, but not to such a marked degree. The vertebral foramina do not, owing to their almost circular shape, show much difference. Of the other parts of the vertebrae, the spinous process and lamina overlap each other in a much lesser degree in the Bushman, thereby allowing a greater latitude of movement in the thoracic region.

Lumbar Region. Vertebrae Lumbales.

The various measurements of the bodies and canals are taken as in the thoracic vertebrae, and the general lumbar index which indicates the amount of curvature of the spine in this region as far as the vertebrae are concerned is also added ; thus:—

$$\frac{\text{Sum of Posterior Vertical Diameters of the Bodies}}{\text{Sum of Anterior Vertical Diameters of the Bodies}} \times 100.$$

EUROPEAN. LUMBAR VERTEBRAE. CORPUS.

No. of Vertebra.	No. 1.			No. 2.			No. 3.		
	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.
1	29	38	25	26	34	21	31	40	27
2	29	38	24	26	34	21	32	42	23
3	31	39	25	27	35	22	33	43	24
4	32	41	24	27	36	23	34	44	23
5	31	42	22	27	38	22	34	46	22
Total	152	198	120	133	177	109	164	215	119
	Length-Breadth Index, 76·7 Length-Depth Index, 79			Length-Breadth Index, 75·1 Length-Depth Index, 82			Length-Breadth Index, 76·2 Length-Depth Index, 7·25		

Average Length-Breadth Index, 76.
Average Length-Depth Index, 77·8.

BUSHMAN. LUMBAR VERTEBRAE. CORPUS.

No. of Vertebra.	No. 1.			No. 2.			No. 3.		
	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.	Length.	Breadth.	Depth.
1	21	27	18	22	28	19	26	38	23
2	22	29	20	23	28	20	27	36	23
3	23	31	20	24	30	21	29	40	23
4	25	33	20	26	34	21	32	42	21
5	25	34	19	27	32	20	32	45	22
Total	116	154	97	122	152	101	146	201	112
	Length-Breadth Index, 75·3 Length-Depth Index, 83·6			Length-Breadth Index, 80 Length-Depth Index, 82·8			Length-Breadth Index, 70·2 Length-Depth Index, 76·7		

Average Length-Breadth Index, 75·2.
Average Length-Depth Index, 81·03.

EUROPEAN. LUMBAR VERTEBRAE. VERTEBRAL FORAMEN.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Length.	Breadth.	Length.	Breadth.	Length.	Breadth.
1	16	22	16	21	15	21
2	14	21	15	22	14	22
3	15	21	14	22	13	21
4	15	22	13	21	13	22
5	15	22	14	21	14	23
Total ..	75	108	72	107	69	109
	Length-Breadth Index, 69·4		Length-Breadth Index, 67·2		Length-Breadth Index, 63·3	

Average Length-Breadth Index, 66·6.

BUSHMAN. LUMBAR VERTEBRAE. VERTEBRAL FORAMEN.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Length.	Breadth.	Length.	Breadth.	Length.	Breadth.
1	14	20	16	18	15	18
2	14	20	15	19	13	18
3	15	21	14	19	11·5	18
4	15	21	15	19	11·5	18
5	16	22	16	21	12	19
Total ..	74	103	76	96	63	91
	Length-Breadth Index, 71·8		Length-Breadth Index, 68·7		Length-Breadth Index, 69·2	

Average Length-Breadth Index, 69·9.

General Lumbar Index of the Vertical Anterior and Posterior Diameters of the Lumbar Bodies.

EUROPEAN.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Anterior.	Posterior.	Anterior.	Posterior.	Anterior.	Posterior.
1	25	27	24	25	24	27
2	26·5	26·5	25	25	27	26·5
3	28	27	26	25	29	26
4	28	25	27	25	30	24
5	28	20	29	23	30	20
Total ..	135·5	125·5	131	123	140	123·5

Sum total of Anterior Vertical Diameters, 406·5.
Sum total of Posterior Vertical Diameters, 372.
General Lumbar Index .. .. .. 91·5.

BUSHMAN.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Anterior.	Posterior.	Anterior.	Posterior.	Anterior.	Posterior.
1	21·5	22	22	21·5	22·5	26
2	23	23	22	22	23	25
3	23	23	24	23	24	25
4	24	22	24	23·5	23	23
5	23	20	24·5	22	24	22
Total ..	114·5	110	116·5	112	116·5	121

Sum total of Anterior Vertical Diameters, 347·5.
Sum total of Posterior Vertical Diameters, 343.
General Lumbar Index .. .. .. 98·7.

The difference in the antero-posterior length of the bodies of the lumbar vertebrae in the European and Bushman is practically negligible, but the central vertical depth of the bodies and the antero-posterior length of the vertebral canals are much greater in the Bushman.

The average of the indices of the vertical diameters of the bodies show a decided difference; thus the European average is 91·5, while the Bushman average is 98·7.

The different races of man have been classified according to this index, thus:—

Kurtorachic—index below 98, displaying a forward convexity; includes Europeans generally, and Chinese.

Orthorachic—index between 98 and 102, column practically straight; includes examples of Eskimo and Maori.

Koilorachic—index above 102, displaying a backward convexity, includes Australians, Negroes, Bushmen, and Andamanese.

It will thus be noted that hitherto the South African Bushman has been placed in the Koilorachic class. Shrubsall's observations (1) pointed out that in the specimens he examined they fell into the second class with straighter spines as far as the bones are concerned.

The present series would seem to support Shrubsall's observations.

In the literature at my disposal I have not observed evidence of inquiry into a similar arrangement as far as the cervical and thoracic vertebral curves are concerned. I have therefore constructed a similar index of the vertical anterior and posterior depths of the bodies of the cervical and thoracic vertebrae.

The following tables would appear to show that the same characteristic as in the lumbar region, namely, that there is no adaptation of the bones to the curves, obtains in the cervical and thoracic regions as well. The adaptation must therefore in the South African Bushman be entirely cartilaginous, for there is reason to believe that the lower races have as strongly developed curves when erect as the higher races. The only proof afforded as yet are Cunningham's section of an Australian spine, and his index of ensellure on living Bush natives. What, it may be asked, does the differences in construction, namely, (1) cartilaginous arrangement, (2) less obliquely placed laminae and spines, (3) narrowness of the bodies in an antero-posterior direction, mean? In higher races the spine has sacrificed flexibility for stability. Lower races have preserved the suppleness essential for their mode of life and needs, hence in the maintenance of the erect attitude the ligamentous and muscular mechanism must be brought more into play than in higher races.

Cervical Vertebrae.

Anterior and Posterior Vertical Diameters of the Bodies.

EUROPEAN.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Anterior.	Posterior.	Anterior.	Posterior.	Anterior.	Posterior.
3	14	14	13	12	13	13
4	13	12	13	12	10	11·5
5	14	13·5	11	12	14	12
6	14	14·5	13·5	14	13	13
7	14	15	13	13	13·5	14
Total ..	69	69	63·5	63	63·5	63·5

Sum total of Anterior Vertical Depths, 196·5.
Sum total of Posterior Vertical Depths, 195·5.
Index .. .. 99·9.

BUSHMAN.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Anterior.	Posterior.	Anterior.	Posterior.	Anterior.	Posterior.
3	10	10·5	9	10	—	—
4	10	10	10	10	—	—
5	10	10·5	10	10	—	—
6	10	10·5	10	10	—	—
7	11	11·5	11	10·5	—	—
Total ..	51	53	50	50·5	—	—

Sum total of Anterior Vertical Depths, 101.
Sum total of Posterior Vertical Depths, 103·5.
Index .. .. 102·5.

Thoracic Vertebrae.

Anterior and Posterior Vertical Diameter of Bodies.

EUROPEAN.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Anterior.	Posterior.	Anterior.	Posterior.	Anterior.	Posterior.
1	16·5	17	14	14·5	16	16·5
2	17	17·5	16	17	18	19
3	17	18	17	17·5	20	20
4	18	19	18	18	20	20
5	18	19	18	19	20	21
6	18	20	18	20	21	22
7	17	20	18	19·5	20	22
8	16	20	18	20	19	22
9	18	20	20	22	21	22
10	20	22·5	20	21	23	23
11	21	24	20	22·5	24	25
12	23	26	22	24	23	28
Total ..	219·5	243	219	236	245	260·5

Sum total of Anterior Vertical Depths, 683·5.
Sum total of Posterior Vertical Depths, 739·5.
Index .. .. 108·2.

BUSHMAN.

No. of Vertebra.	No. 1.		No. 2.		No. 3.	
	Anterior.	Posterior.	Anterior.	Posterior.	Anterior.	Posterior.
1	13	13·5	12	11·5	—	—
2	14	14	14	13	—	—
3	16	15	15	14	—	—
4	16	15	16	16	—	—
5	16·5	16	16	17	—	—
6	17	16·5	17	18	—	—
7	18	17	18	18	—	—
8	18	18	18	18	—	—
9	18	18	19	18·5	—	—
10	19	19	19	18·5	21	21
11	19	20	19	20	20	22
12	20	21	20	19	21·5	23
Total ..	204·5	203	203	201·5	—	—

Sum total of Anterior Vertical Diameters, 407·5.
Sum total of Posterior Vertical Diameters, 404·5.
Index .. .. 99·2.

Sacrum.

The measurements and indices utilized in the study of the sacrum are as follows :—

1. Sacral Index =

$$\frac{\text{Breadth of base of sacrum} \times 100.}{\text{Length from middle of promontory to middle of anterior-inferior border of fifth sacral vertebra.}}$$

The length is measured with callipers, but Cunningham (Glasgow, 1900) pointed out that this could not be regarded as the true length, for it did not take into account the curve of the sacrum, often a very considerable factor and showing racial character. He therefore suggested that the length should be measured from the points mentioned above along the concavity with a steel tape held in position by a flexible strip of lead. I append a table from Professor Cunningham's Lectures to his class of Anthropology in Edinburgh University, of which I was a member, showing the differences between the indices constructed from the callipers and tape measurements, and how the index largely depends on the condition of the curve.

	Calliper Index.	Tape Index.	Curve Index.
Irish Female, A	125·7	108	19·4
Irish Female, B	158·3	110	32
Irish Male, A	110	96·6	22·5
Irish Male, B	126·7	98·4	28
Torres Straits Male	108	100	17·5
Torres Straits Female	115	101·8	19·5
Andaman Male	118 7	106·3	17·8
Negro	103·5	97·5	11·5
Australian	89	86·6	11·6
Chimpanzee	82·5	80·6	5·6

2. Sacral Curve Index =

$$\frac{\text{Depth of curve from deepest part of curve to line joining middle of promontory to middle of anterior inferior border of fifth vertebra} \times 100.}{\text{The length of curve measured by flexible tape.}}$$

SACRAL INDEX.

	S.A.C. 1. Female.	S.A.C. 2 Male.	S.A.C. 3. Male.
Sacral Length, Callipers.. ..	99	93	103
Sacral Length, Tape	106	98	105
Sacral Breadth	99	94	92
Callipers Index	100	101	89·3
Tape Index	93·4	95·9	87·6

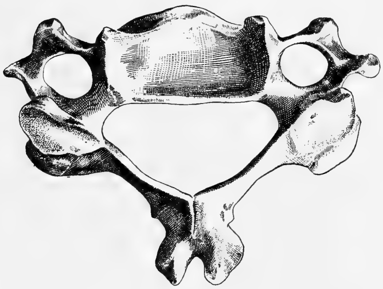
SACRAL CURVE INDEX.

	S.A.C. 1. Female.	S.A.C. 2. Male.	S.A.C. 3. Male.
Length of Curve, Tape	106	98	105
Depth of Curve	20	16	12·5
Index	18·8	16·3	11·9

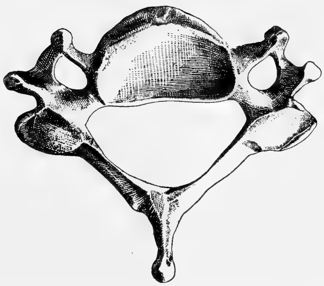
Average Index in S.A. Bushman, 15·6

Compare with Cunningham's Table :—

Irish Females (2)	25·7
Irish Males (2)	25·2
Torres Straits Male	17·5
Torres Straits Female	19·5
Andaman Male	17·8
Negro	11·5
Australian	11·6
Chimpanzee	5·6

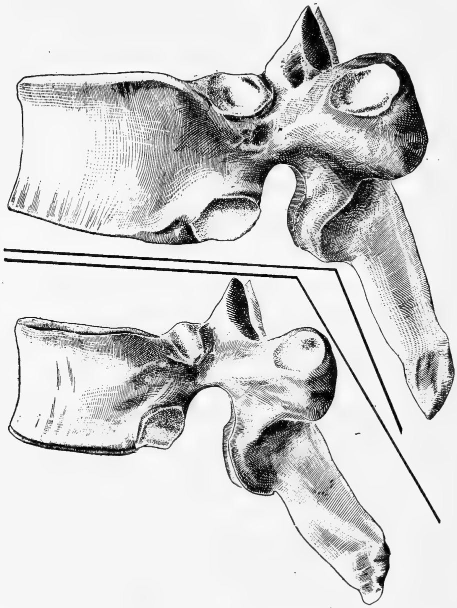


No. 1



No. 2

No. 1 European, and No. 2 Bushman, fifth cervical vertebra, illustrating differences in the spinous processes, bodies, and the vertebral foramina.



No. 3

No. 4

No. 3 European, and No. 4 Bushman, eight thoracic vertebrae, illustrating differences in the vertical anterior and posterior diameters of the bodies, and also the relatively less oblique direction of the laminae and spinous processes in the Bushman as shown by the angles between the lines projected through the centres of the bodies and spinous processes.

NOTES ON N'GAMILAND.

By A. G. Stigand.

(Read May 21, 1913.)

The accompanying Prismatic Compass Sketch Map of a traverse which I made in N'gamiland during January–March, 1911, from Tsau to the Chobe River, to which has been added a previous traverse from Toteñ to the Mababe by water, may prove of interest.

Administratively, N'gamiland is the North-Western District of the Bechuanaland Protectorate. The Batawana Reserve constitutes about three-quarters of this area, the northernmost portion thereof, and includes Lake N'gami. It is by far the most interesting part on account of the river-system of the Okovango, which river annually during the winter months—June to September—floods a vast area of country, the flood water resulting from the heavy summer rainfall in the countries to the north, Portuguese West Africa in particular, which the Okovango brings down, but which, owing to the flatness of the country, especially the almost dead level from about 18° 50′ S. Lat. southwards, travels very slowly. It is also interesting because of Lake N'gami itself, which to-day has almost entirely dried up, with the exception of a little water that flows into its eastern end during the flood season, and is a vast reed bed which itself has been gradually contracting its borders during the last decade owing to this desiccation.

I here take the liberty of quoting from a description by Major E. J. Lugard, D.S.O., which appeared in the Kew Bulletin (No. 3 of 1909) :—

" Broadly speaking, Lake N'gami may be considered the northern limit of the Kalahari Desert, and the southern and lowest point to the S.W. of an inland river-system which finds no exit to the sea. The drainage, therefore, is towards this depression to the S.W., and towards the Makarikari Salt-pan which is at a still lower level some two hundred miles to the S.E. Lake N'gami is now in the intermediate stage between a lake and a salt-pan, of which latter there are many in the Kalahari Desert to the East.

" Space does not admit of more than a slight reference to the remarkable river-system of the country lying immediately north of Lake N'gami.

It consists of a network of rivers and reed-grown swamps, of which the Tamalakan and the lower reaches of the Okovango are the extreme east and west channels. They are essentially the same river, linked up by innumerable channels."

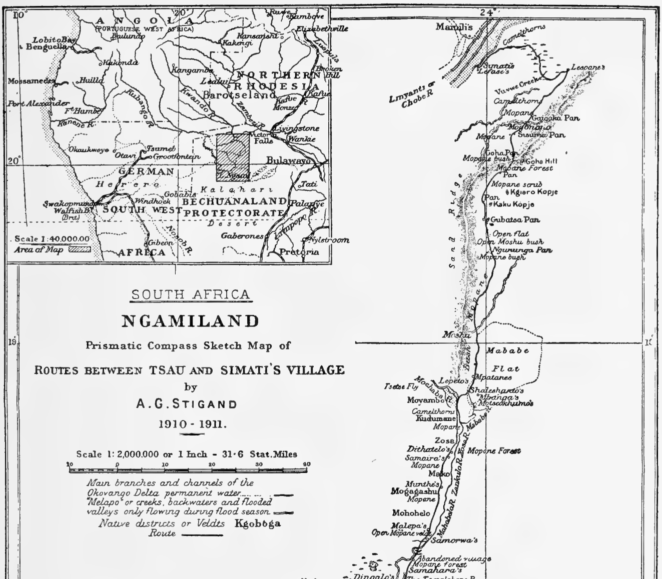
The boundaries of the Batawana Reserve were defined by the High Commissioner's Proclamation No. 9 of 1899. Its limits are, on the north, the narrow 20 miles wide German strip known as the "Caprivi Zipfel," on the east the 24th meridian of E. Long., on the south the 21st parallel of S. Lat., and on the west the 21st meridian of E. Long.

Roughly speaking, the Okovango River enters the Batawana Reserve towards its north-western corner, and flowing in one strong stream—averaging during the winter season 650 yards broad by 16 feet deep—in a S.S.E. direction, it begins to overflow its banks at 18° 21′ S. Lat. and then spreads out fan-wise into many channels and swamps at about 18° 50′ S. Lat. From the latter point southwards, owing to the level country, they continue to spread out until they attain a width of some 100 miles (in the winter season) just before reaching the 20th degree of S. Lat.

According to Dr. Passarge, and Seiner, there can only be a difference of some two or three metres between the altitude where the 19th parallel cuts the Okovango, and Tsau (south of the 20th parallel) and Lake N'gami.

Most of the main branch channels are perennial in their flow, running in comparatively deep beds, but are, of course, low during the summer months, when the small local rainfall of N'gamiland (recently about 16 inches per annum) has little effect on them. On the other hand, large swamp areas and countless creeks, valleys, backwaters, etc., which are running and full during the winter flood season, are quite dry the rest of the year. To the former perennially flowing channels the Batawana apply the Sechuana word "noka" (river) in contradistinction to "molapo," meaning a wet valley, a creek, or a backwater, or a swamp, which they apply to all of the second-mentioned non-perennial watercourses. For brevity, I will hereafter refer to "river" and "molapo," as the case may be.

The bulk of the Okovango water is carried down in the easternmost rivers, and to-day no water reaches Lake N'gami by the extreme western ones. The Okovango—or rather "Kovango," as it is named by the Mampukushu who live on it in the neighbourhood of the 18th parallel of S. Lat.—is named the "Taoge" (the "g" in Sechuana is pronounced as in loch) by the Batawana, the whole length of its course from Portuguese West Africa, and they look upon the westernmost river of its swamps as its main channel, which they recognize as the Taoge down past Tsau and thence down its smaller westernmost branch, locally known as the Dobe River, and a mile and a half further down as Moshwana-oa-kubo


SOUTH AFRICA
NGAMILAND
Prismatic Compass Sketch Map of
ROUTES BETWEEN TSAU AND SIMATI'S VILLAGE
by
A.G.STIGAND
1910 - 1911.
Scale 1: 2,000,000 or 1 Inch - 31·6 Stat.Miles
Main branches and channels of the Okovango Delta permanent water
"Melapo" or creeks, backwaters and flooded valleys only flowing during flood season
Native districts or Veldts Kgoboga
Route
ANGOLA
(PORTUGUESE WEST AFRICA)
NORTHERN RHODESIA
Barotseland
GERMAN SOUTH WEST AFRICA
BECHUANALAND PROTECTORATE
Kalahari Desert
Scale 1:40,000,000
Area of Map
Lobito Bay
Benguella
Mossamedes
Port Alexander
Livingstone
Victoria Falls
Bulawayo
Windhoek
Gobabis
Gaberones
Pretoria
Elizabethville
Mamili's
Simati's
Lmyantsi or Chobe R
Leaoane's
Gaigaka Pan
Sand Ridge
Mosha
Mababe
Flat
Tsetse Fly
Moyambo
Kudumane
Zosa
Mopane Forest
Mohohelo
Samorwa's
Abandoned village
The Tamalakane R. originates in a swamp here
Under water during flood season
Dingalo's
Palm trees
Tamalakane R.
Mopane
Lekawa Drift
Gumku R.
Masheta's
Kgwapuk
Moporota
Ngaraga
Tsetseku
Kgoboga
Botletle R.
Tsau
Dobe Drift
Nakalechwe
Formerly main channel of the Okovango
Mimosa forest
Setata Pan
Mamatau Pan
Machaba
Maolane
Toting
Nhabe or Lake R
Lake Ngami
The shaded portion in L. Ngami shows approximately the extent of water in Aug 1910.
The Lake R. flows west during the flood season, when the Kunyere and Tamalakane Rivers are high. When they are low and the water not high enough to clear the sand bar between Toting and the lake, it is dammed and the surplus water from the Kunyere flows in the Lake R. Channel eastwards to the Botletle.
Mabele-a-pudi Hills
Kwebe Hills
Nwana-lekau Hill
23°
24°
20°

(hippo rivulet), and lower still, as the Mokolane (palm-tree) river, where this small branch ends to-day ingloriously in a small swamp some 13 miles short of the north-western margin of the Lake basin. Its failure to reach the western end of the Lake to-day is no doubt partly attributable to diversion of the channels to the north through silting up, but chiefly, I think, to the fact of the generally greatly decreased volume of water discharged by the Okovango during recent decades. When Livingstone discovered the Lake in 1849, this Taoge, or westernmost river, was—according to old natives who were young men when the "Doctor" came to the Lake—"a large river," and from what the old Makuba state that their fathers told them, the Okovango brought down annually a much larger volume of water both by the western and by the eastern rivers during the period (about) 1800–1850 than it has done since, and that even when Livingstone came the flow had markedly decreased.

It appears that the westernmost river, the Taoge, ceased running into the Lake at the end of the reign of the Batawana Chief Letsholathebe (about the end of the seventies) and that when his son Moremi succeeded him, about 1880, it had completely dried up south of the "Mokolane."

The only water that reaches the Lake to-day flows into it at its eastern end, and then only when the Kunyere and Thamalakane Rivers are in high flood. When the Kunyere and Thamalakane Rivers are both very full, the whole of the Kunyere water and a portion of the Thamalakane water run into the Lake. The Thamalakane, which is the largest of all the branch rivers, when very full, divides its water at its junction with the Botletli and Lake River, the larger portion thereof flowing eastwards down the Botletli and the smaller portion along the Lake River to the Kunyere confluence at Toteñ, thence into the Lake together with the Kunyere water. On the other hand, when the Thamalakane and Kunyere Rivers are low, all the water of the former flows down the Botletli, and the water of the latter, being dammed by the sand-bar in the bed of the arm of the Lake (also called the Lake River) between Toteñ and the Lake mouth, makes its way eastwards to the Thamalakane-Botletli junction, there joining the Thamalakane water down the Botletli.

N'gamiland, generally speaking, is divided into two zones: the River-system zone and the Sandbelt zone. In the former zone tropical vegetation predominates, and in the latter the sub-tropical vegetation of the Kalahari.

As to the tropical vegetation, two species of palm are plentiful on the countless islands in the swamps—especially in those areas north of the 20th parallel where there is always water—namely, the tall fan-leaved "Mokolane" or Borassus palm, and the short "Tsaro" palm, with its feather-shaped leaves; and generally, in the river-system zone, the *Kigelia pinnata* (locally named the "Moporota") with its huge, pendant sausageshaped fruit and claret-coloured flowers; the stately "Mokuchon"-tree and the "Mopororo"-tree (out of the trunks of these last three trees the Makuba make their dug-out canoes, the Morporota being considered the best); the "Mochaba," a *Ficus*, together with others of the *Ficus* family; vines of various kinds; and lastly, the *Adansonia digitata* or Baobab, which is found in both zones.

With regard to the sub-tropical vegetation of the sandbelts, the various kinds of thorny acacia predominate south of the 20th parallel of S. Lat., amongst which the largest is the *Acacia giraffae*—in South Africa wrongly named the Camelthorn, owing to the Dutch having misnamed the Giraffe the "Kameel," whereas *Camelopard* was meant; in the same manner the leopard (*Felis pardus*) has been misnamed the "tiger." Among the other kinds of thorny acacia the more noticeable are the "Mōshu" and the "Mōōka" (mimosa, or sweet-thorn), the latter growing near dongas and watercourses which run during the rains. Of other trees, not thorny, the "Mocwerè" (the Hardekol of the Boers), the "Mogonono," which grows in very loose sandy ground (the Makuba exclusively cut their punting poles from this tree); the "Mogkwa," or native teak, but this only grows in a few parts in the N.W. of the Batawana Reserve north of the 20th parallel. North of the 20th parallel the *Copaifera mopane* predominates, in fact the country between Lake N'gami and the Linyanti or Chobe River is almost entirely Mopane veldt, and, as it is well known, where this tree grows it excludes every other kind of vegetation, including other undergrowth.

As to the Batawana tribe and its origin. The Batawana are an offshoot of the Bamangwato, a Bechuana tribe of which the well-known Khama is chief to-day. Somewhere about the year 1800, Tawana, a brother of a former Chief Khama, an ancestor of the present one, quarrelled with his brother and seceded from him together with his followers. They made their way through the Kalahari to Lake N'gami where they settled, taking possession of the country, the Makuba, the inhabitants and aborigines of N'gamiland, a timid fishing people inhabiting the river-system, offering no resistance. Tawana, in the Sechuana language is the diminutive of Tau (lion). Ba-Tawana = the people of Tawana.

The Makuba, Makhalahadi and Masarwa (Bushmen) in N'gamiland are subject to and servants of the Batawana.

The Makuba inhabit the river-system and the Makhalahadi and Masarwa the sandbelts.

The Makuba are of fine physique, with muscles well developed from punting their dug-out canoes in the swamps from childhood, but are of a timid and childlike disposition, and a very stay-at-home lot. In punting they excel, but as they confine their navigation as much as possible to the shallows, avoiding deep water as much as they can, they are poor performers with the paddle—in this respect unlike their neighbours to the north, the Mampukushu, who are experts with it. On a former journey by water up the Okovango to Dibebe's (Andara) in April, 1910, I was struck with the skill of the Mampukushu in negotiating the rapids of the Okovango, which they navigate, both up and down, two men standing in the canoe using the long paddle, or oar, with great dexterity. Some Makuba, who had reluctantly accompanied me as far as the beginning of the rapids at Popa and who were much alarmed at the big river, which they had never seen before, were very astonished at the performances of the Mampukushu.

Ramokwati, an old Mokuba over eighty years of age, the grandson of Zankotse, who was the chief of the Makuba when Tawana and his people arrived at the Lake, states that the Makuba were more numerous in those days, having been subsequently decimated by some epidemic. He says that a large number lived on the shores of the Lake, Zankotse's village standing where Ramotsamaesi's village stands to-day on the Lake River; and the Lake was a vast expanse of open water, and that Makuba who plied with their canoes on it were often swamped by the waves and lost; that Tawana was friendly with the Makuba and did not exact tribute from them and make them his servants as he and his people were anxious that the Makuba should teach them "to go on the water in canoes"; that it was subsequent chiefs who made them servants.

The river-system of N'gamiland abounds in fish, chiefly perch of many varieties. Mr. R. B. Woosnam, who collected specimens in N'gamiland in 1909 on behalf of the British Museum, obtained, I think, 13 varieties of perch. Besides perch, there is the ordinary South African "barbel," or "toni" as the Makuba call it; a small kind of pike; and in the main stream of the Okovango, the "tiger fish," a black and silver spotted fish of pike habits, scaling frequently 12 lbs. and upwards. This last gives good sport, casting and trolling, with the pike rod. The Makuba fish chiefly with the net, which they manufacture from string made from the fibre of an aloe, the "mokgotse," which is plentiful in many parts of N'gamiland, as well as from the "maq̈anq̈awa," a prickly stemmed plant about 6 feet high growing on the banks of islands in the swamps some distance to the north of Tsau and which is not so plentiful. The net is soaked in a red dye made from the inner bark of the "Mōōka"-tree to preserve it from rot. Small bunches of "madinti," a water-rush, are used as floats. Having extended the net in shallow water the fish are driven into it by Makuba approaching in canoes beating the water with their punt poles. They also catch fish to a large extent with fish traps, both fixed and portable. The former are erected in running channels in the shape of a stockade made of reeds across the stream, with sundry (in plan) heart-shaped enclosures with narrow openings at the V, at the top of the heart, as it were; the fish after entering are unable to find their way out again. The portable traps are basket-shaped, the smaller kind made of "chita" rush, and the larger of reeds. The Makuba also spear fish.

They seldom wear European clothes, wearing a strip of steenbuck leather about the middle, worn, like the Masarwa, bathing-drawers fashion, but with a butterfly-like ornament behind consisting of a pair of wings about 6 inches in diameter of untanned steenbuck skin with a white border. This typical Makuba ornament looks rather quaint and neat. They also make themselves leather jackets, sleeveless as a rule, out of pala or reedbuck skin, and straw hats out of grass.

Following the Batawana, a fair percentage of Makuba profess Christianity to-day. They have no religion of their own, but merely believe in the existence of a Supreme Being. Different groups of them, like other tribes, have their totems among the antelope or other wild animals, but this is unconnected with any kind of religious worship. Their law of succession used to be—as it is with the Mampukushu to-day—through the female line; the eldest son of the eldest sister of the deceased male being the heir. But now the majority have adopted the Batawana law of succession through the male line.

The Batawana, like other Bechuana, wear European clothes, which they began to adopt as long ago as the seventies. They are mostly Christians. The work of conversion begun by Livingstone during his short stay at the Lake on his way to the Makololo being continued by Khukwe, a native missionary installed by him at the Lake, and in later years by Mr. Wookey.

Up till the middle of the eighties the Batawana lived at the eastern end of the Lake, the spot called Toteñ to-day—the name being a contraction of Matoteñ, or Matlotleñ as it should be in Sechuana, but the Batawana drop the "l" sound in all Sechuana words with "tl." Matlotleñ is the locative case of Matlotla (abandoned and ruined huts).

Under the Chief Moremi, in consequence of the two Matabele raids on them, the Batawana in 1886, just after the second raid, moved their village to Nokaneñ, on the Okovango, 45 miles north of Tsau, thence to Komokaku, thence to Nakalechwe, and thence to Tsau, where they dwell to-day under the young Chief Mathiba, son of Moremi, who was installed by the Government as chief in 1906 in place of Sekgoma, his uncle, who, for political reasons, was deposed and deported. Tsau is 462 miles by road from the railway, at Palapye Road Station, the journey occupying five to six weeks by ox-wagon. Its altitude is, according to Dr. Passarge, 2,969 feet (950 metres) above sea-level, and that of Lake N'gami the same.

On the occasion of the Matabele raid in 1886, the Batawana with their cattle took refuge on an island in the swamps, to which their Makuba piloted them, and which was only fordable—neck deep—from one point, being inaccessible to the Matabele, who had no canoes, from other sides owing to the deep water and dense reeds and rushes. The Batawana being well armed with rifles and ammunition took up a strategical position on the bank of the island, under cover of the reeds commanding the narrow channel of approach, and were successful in driving off several determined attacks by Lobengula's impi, who, hampered by the deep water and reeds, were at the mercy of the rifles of their enemy and suffered considerable losses, the wounded being finished off in the water by the crocodiles and by the Batawana when the Matabele had retired, which the latter eventually did, much exasperated by hearing the lowing of the Batawana cattle safely kraaled in the centre of the island, since it was for the cattle that Lobengula had sent them.

Tsau, the name of the present Batawana village, which takes its name from the particular "veldt" in which it is situated, is a Sesarwa or Bushman word (pronounced Qao—the "Q" representing a linguo-dental click) meaning "many buffaloes."

The Batawana all reside at Tsau, except when visiting their outlying cattle-posts and cornfields, or when a few occasionally go out hunting for a few weeks. Most of the women spend half the year away at the cornfields where there are summer huts and little villages, returning into Tsau for the winter. The corn grown is "Kafir corn," or *Sorghum vulgare*. The Motawana young man of to-day has degenerated, in character and stamina, partly the result of in-breeding, but chiefly through his inactive and unmanly life, doing nothing, and is an inferior being to the old men, who were brought up in a stricter and manlier school and with a severer parental discipline.

As to the races in the Batawana Reserve subject to the Batawana, besides the Makuba, there are on the sandbelts, as stated, Makhalahadi and Masarwa. Both of these have been described by others. Concerning the nomadic Mosarwa, or Bushman, of the Kalahari, he has been so often described that there is nothing new with regard to him that I can contribute, excepting the following one bit of information, and that is the detailed process by which he makes the poison for his arrows, since, as far as I am aware, no European has hitherto discovered it in detail. It is as follows :—

The Mosarwa in the Batawana Reserve first seeks out a certain thorn-bush in the sandbelt which he calls "Doru"* (the Batawana have no name for it, as they do not know it, at least the majority of them). This

* The "Doru" bush is the bush used by Masarwa in N'gamiland, roughly North of Latitude 20° 30′. South of this, in the Kalahari proper, it is not to be found and another is used.

bush grows to about 4 feet high and spreads out a good deal. It is, but for the thorns, something like a diminutive "Mochaba." If you strip the bark off a red gum exudes. It has white thorns about 2½ inches long, and is to be found in many of the higher parts of the sandbelt. If you watch the leaves of this bush, grubs or caterpillars will be observed feeding on it; these drop to the ground and bury themselves in the sand where they encase themselves in a kind of cocoon. The Mosarwa, during the winter months, digs under this thorn-bush and secures these cocoon-encased grubs. He then breaks the cocoon and extracts the grub, which is a small flattish grey-coloured grub about 3 millimetres long. He severs its head and dries the body in the sun. He then grinds to powder the dried grub bodies in a saucer-shaped bone, usually using a concave section of bone from the neck portion of the spinal column of a giraffe as the saucer, or mortar, and a stick of bone for a pestle. He next seeks out a "Moñana" thorn-bush (*Zizyphus mucronata*), so well known to English colonists as the "wait-a-bit" thorn, and to the Boers as the "haakdoorn," which is very common in the Bechuanaland Protectorate, the Western Transvaal, and Bechuanaland, and which grows to a height of from 7 to 16 feet. He now performs the second stage of his process in either of the following two ways, as may happen to be most convenient at the time. He either

(1) Cuts down the "Moñana" bush and cuts out a length of the trunk (which in the average-sized bush is about as thick as a man's arm) which he places on a fire with the end projecting. Under this projecting end he places the bone saucer containing the powdered grubs. The sap of the "Moñana" then oozes out at the end of the piece of trunk and drops into the saucer. Or else

(2) He tears off the outer bark of the "Moñana" so as to get at the inner bark or skin; a piece of the latter he tears off and chews in the mouth spitting it out into the saucer containing the powdered grub.

He thoroughly stirs up and mixes the compound, then smears his bone or iron arrow-heads with the concoction, twice, letting it dry after each application, and after dusting on to it a few of the heads of the grubs (the latter for luck, one presumes). The concoction dries into a dark-brown crust.

They state that this poison remains active for about two years. A Mosarwa can tell whether the poison on an arrow-head is still active or not by smelling it. An antelope, say an eland, hit with one of these poisoned arrows may perhaps travel 40 miles or even 70 miles before it dies, getting slower and weaker as it goes. On these occasions the Masarwa with their women and children, and all their household belongings (generally a pot and a few skins), move their residence and follow the spoor of the wounded animal until it finally drops and dies. The

Masarwa say that the meat remains quite good for a day or two, but if the carcase is left longer it swells very much and the meat goes rapidly bad. One concludes that it must get very bad indeed, since meat of a carcase that has become putrescent in the ordinary way, and which is in such a state of putrefaction as to cause the average European to make a detour in the veldt to avoid it, is most palatable to the Mosarwa, who doubtless looks upon such well-hung game as a dainty dish with plenty of flavour to it. Whilst on this subject it may be mentioned that also the Makuba and the River Masarwa have not the slightest objection to well-hung fish. When you are being punted by them in the swamps they will with loving care recover the decomposed body of a fish floating on the water and preserve it in your canoe where it loses no time in announcing its presence, which you take care is not unnecessarily prolonged.

With regard to the arrow poison of the Masarwa, I have not found any of the Batawana who knew the process of preparation, except one old man who used to hunt with his father's Masarwa servants from childhood, and he knew the general process but not in exact detail. The reason for this is, presumably, that the matter is of no particular interest to the Batawana, since they have used firearms in hunting for the last forty years or so, and doubtless have not taken the trouble to find out.

Besides the ordinary Sandbelt Mosarwa, there is in N'gamiland another species of Mosarwa, the River Mosarwa, who lives on the river-system in fixed villages in the same way as the Mokuba, and who, like him, lives chiefly by fishing. His language is similar to, but different from, that of the proper Mosarwa. He is darker in colour, in shade between the yellow-brown of the Mosarwa and the black of the Mokuba, and is no doubt the result of a former cross between the two. The River Mosarwa, when fishing fails, hunts in the veldt, but is, as one would expect, inferior to the Sandbelt Mosarwa as a tracker, veldtsman, and hunter. Like the Mokuba, he is very "parochial" in his peregrinations, and seldom knows the veldt beyond the limits of his own "naga" (veldt), or small district. I have seen many of them get completely lost in the veldt once beyond their little radius of 10 miles from their village on the bank of a river or swamp.

With regard to the journey made in July–August, 1910, from Tsau to Mababe, the portion from Tsau to Toteñ was performed with cart and oxen, the southern more circuitous road being taken to avoid flood water which extended from Tsau to beyond the Mapenoñ River at the time.

Nine and a-half miles from Tsau the Mokolane rivulet, ending in a small swamp, was forded. This channel, as stated above, up till the end of the seventies flowed into the Lake at its N.W. corner as a large river: as large as the Thamalakane is to-day, the old men say, and is still looked upon as being the Taoge River, or main channel of the Okovango. The ocal names it bears successively in the neighbourhood of Tsau, viz., Dobe-River, Moshwana-oa-kubo, and Mokolane, is a way rivers have in N'gamiland, where they generally take the name of the "naga," or "district," through which they run. It may here be remarked that the whole of N'gamiland, including the swamps, is divided up into "dinaga," or veldts, some being large areas and others again absurdly small. These "districts" are named after some predominating vegetation, or feature, or from some event that took place in them in the past—the latter being frequently of a most trivial nature. Although the Dobe-to-Mokolane channel is referred to, especially by the older men, as the Taoge, other rivers are not so fortunate and change their name during their course without any clue to their identity, *e.g.*, the Mohohelo River.

Sixteen miles from Tsau the Maputle River, which is the Mapenoñ higher up, is forded. This is a branch of the Taoge.

On emerging from the ugly Mōshu and Mōōka scrub into the open sandy flat bordering the "Lake," there is nothing to be seen but a sea of reeds with the distant Mabele-a-pudi and Kwebe hills (porphyry) beyond. These are the only kopjes seen on the whole journey to Mababe. Between the Mababe and the Linyanti River the next kopjes to be seen are the Gubatsa hills.

The aneroid altitudes along the Lake given on the sketch map are merely relative to one another. Dr. Passarge makes both Tsau and the Lake 2,969 feet above sea-level (950 metres).

The name N'gami is from "N'ama" (with a linguo-dental click after the "N" sound) which in the language of the Makuba means—as one expects in African lake-names—"Lake." The Batawana have Sechuanized the word into "Ñhabe," which is their name for it.

On returning from the Mababe in August, as there was that season a good flow of water from the Kunyere and Thamalakane Rivers into the Lake, and the natives were of opinion that more water had run into it than there had been therein for several years past, the Lake was visited by canoe, proceeding down the Lake River from Toteñ—the last part of this channel, on account of the slope of its bed into the Lake, runs very swiftly—then by a swift and fairly deep open channel, averaging 10 yards in width, through the reed bed, which gets slower in current until at about 8 to 9 miles from Toteñ the channel ceased and the water became very shallow, breaking up into little runlets winding among the reeds. After about 100 yards along one of these runlets the water became too shallow for further progress by canoe, although the latter only drew 9 inches. On getting out and wading amongst the thick aquatic vegetation and reeds for another $\frac{1}{4}$ mile, the water got shallower as one went on, and one came to the conclusion that there was nothing to see and also that the shallowing water could not extend at the most more than $\frac{3}{4}$ mile to a mile further westwards in the Lake, beyond which point the reeds depended, no doubt, for their existence on the moisture that the "Lake" bed absorbs from the small local rainfall in summer.

Old Ramokwati and other old Makuba state that as the Lake dried up from the western end and the bed was exposed, they found stumps of Mocwere and other sandbelt trees that had been once growing there, thus showing that at some period—prior to Makuba tradition—there had been woodland there which must have subsequently been submerged.

Most years, August to November, there is splendid duck-shooting at Toteñ, large numbers of duck flighting from the Kunyere to the Lake. Of these there are at least 13 varieties, including the Pochard, the South African teal, widgeon, tree duck, &c., and also spur-winged geese, knob-nosed, pigmy, and Madagascar geese.

From Toteñ to the neighbourhood of the Mababe the journey was made by boat.

The depression of the Mababe Flat must be slightly under 3,000 feet altitude, that is to say, about the same altitude as Tsau. During the winter months herds of tsessebe and blue wildebeeste are to be seen on the flats, as well as an occasional troop of zebra.

The second journey from Tsau to the Linyanti River was performed with cart and oxen the whole way, fording the Kunyere at Toteñ and, further on, swimming the oxen and floating the cart across the Thamalakane River at the Lekawa Drift, where the Matabele in the eighties crossed on a raft improvised with reeds. This point is referred to by the Batawana as Lekaweñ (the locative case of Lekawa "raft").

The other rivers crossed were fordable at that time of year, none of them being over 4 feet deep, but several necessitating having the cart unloaded and the contents carried or canoed over.

The "melapo" with the exception of those on the Chobe, were dry, of course, on the second journey.

The only stone seen on the second journey, with the exception of the distant view of the Kwebe hills, and the Gubatsa and Goha hills passed North of Mababe (which are also porphyry, I think), are a few small patches of limestone outcrop, which are marked on the map.

As to game, I will confine myself to that which is to be met with on the actual route traversed. During the summer months very little game is to be seen, for when there is rain-water in the pans in the sandbelt, the game which, with the exception of the eland who does not drink, congregate near the rivers and melapo in winter, scatter far and wide over the sandbelt. During the winter months the following may be met with: giraffe, eland, tsessebe, blue wildebest, zebra, pala, kudu, a few roan and also sable antelope, a few waterbuck. On the Thamalakane and other rivers some hippo are occasionally to be found. Reedbuck and lechwe are fairly plentiful, fairly large herds of the latter being frequently met with. Bushbuck are also seen in a few parts. Sitatunga is not to be found, its habitat being in the heart of the deep swamps to the west. Warthog are fairly plentiful in many parts. The various antelope mentioned are only found in certain parts of the route, of course, and within their own particular limits. With regard to the larger carnivora: lion, leopard, hunting-leopard or chitah (not often actually seen), hyaena, crocuta, and hunting-dog. The leopard is to be found chiefly in the hills, but also on the river-system, especially on islands in the swamps where it preys on lechwe. These leopards seem almost as much at home in water as on land, being powerful swimmers. When hunted, they swim in the deep water through the reeds from island to island, and, when so escaping, generally baffle pursuit.

Game is protected by the Government. The hunting rights of the Batawana, which they were allowed to retain, are vested in the chief, who, before white administration came into the country, was, according to old Bechuana law, sole owner of his country and all that is in it, including the trees and the soil; and the Chief Mathiba, like his neighbour Khama, actively co-operates with the Government in the preservation of the game, giving very limited permission to his people at present to hunt, except in respect of the smaller and more numerous antelope such as steenbuck, duiker, lechwe, and pala.

Crocodiles abound in the rivers and swamps, but are seldom actually seen in winter, owing to their bashfulness (above the surface, one should add), but may often be seen in summer basking in the sun on sandbanks.

The small villages shown on the map north of the Lake are, with the exception of some of the Batawana outlying cattle-posts, mostly Makuba villages, excepting Gwangi's and those in its immediate vicinity, which are inhabited by Manaye—a fishing tribe from the Chobe which settled in Batawana country several generations ago—and some Massubia—an offshoot of the Mampukushu—at M'banga's village, Mababe, and along the Linyanti; these last settled in N'gamiland some fifty years ago, having fled from Barotseland on account of oppression at the hands of the Barotse.

In conclusion, it may be remarked that the young chief of the Batawana is progressive in his ideas and anxious to conduct things in his country according to English views.

NOTE ON CLEBSCH'S THEOREM REGARDING THE SECOND SET OF JACOBIANS DERIVED FROM $n+1$ HOMOGENEOUS INTEGRAL FUNCTIONS OF n VARIABLES.

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(Received June 25, 1913. Read July 16, 1913.)

1. The theorem in question, which was originally published in *Crelle's Journ.*, lxix., pp. 355–358, and lxx., pp. 175–181, was enunciated by its author in the following form: *If* $u_1, u_2, u_3, \ldots$ *be* $n+1$ *homogeneous integral functions of the* m*th degree in the* n *variables* $x_1, x_2, x_3, \ldots$; *and* $v_1, v_2, \ldots, v_{n+1}$ *be the set of Jacobians formed from the* u's: *and* $w_1, w_2, \ldots, w_{n+1}$ *be the set similarly formed from the* v's; *then the* w's *differ from the* u's *by a common factor only—that is to say*

$$w_1 = M.u_1, \quad w_2 = M.u_2, \quad \ldots, \quad w_{n+1} = M.u_{n+1}.$$

Clebsch's mode of establishing it was to show that for any values of the a's and b's the determinant

$$\begin{vmatrix} \dfrac{\partial v_1}{\partial x_1} & \dfrac{\partial v_1}{\partial x_2} & \cdots & \dfrac{\partial v_1}{\partial x_n} & a_1 & b_1 \\ \dfrac{\partial v_2}{\partial x_1} & \dfrac{\partial v_2}{\partial x_2} & \cdots & \dfrac{\partial v_2}{\partial x_n} & a_2 & b_2 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ \dfrac{\partial v_{n+1}}{\partial x_1} & \dfrac{\partial v_{n+1}}{\partial x_2} & \cdots & \dfrac{\partial v_{n+1}}{\partial x_n} & a_{n+1} & b_{n+1} \\ \cdot & \cdot & \cdots & \cdot & \Sigma a_h u_h & \Sigma b_h u_h \end{vmatrix}$$

vanishes identically: that consequently

$$\Sigma b_h u_h \,.\, \Sigma a_k w_k - \Sigma a_h u_h \,.\, \Sigma b_k w_k = 0 ;$$

and that finally "by putting the coefficients of the products $a_h b_k$ separately equal to zero" there results

$$u_h w_k - u_k w_h = 0,$$

as desired.

Even as thus epitomized the procedure is seen to be artificial and somewhat arbitrary: and I therefore propose to put on record a quite simple and more direct treatment, giving also as introduction the lemmas on which both demonstrations rest. For the sake of economizing space n will be taken equal to 3.

2. *If* u_1, u_2, u_3, u_4 *be homogeneous functions of the* m*th degree in* x, y, z, *and*

$$v_1 \equiv J(u_2, u_3, u_4), \quad v_2 \equiv -J(u_1, u_3, u_4),$$
$$v_3 \equiv J(u_1, u_2, u_4(, \quad v_4 \equiv -J(u_1, u_2, u_3);$$

then

$$u_1 v_1 + u_1 v_2 + u_3 v_3 + u_4 v_4 = 0. \qquad (a)$$

This is the same as to say that

$$\begin{vmatrix} u_1 & \frac{\partial u_1}{\partial x} & \frac{\partial u_1}{\partial y} & \frac{\partial u_1}{\partial z} \\ u_2 & \frac{\partial u_2}{\partial x} & \frac{\partial u_2}{\partial y} & \frac{\partial u_2}{\partial z} \\ u_3 & \frac{\partial u_3}{\partial x} & \frac{\partial u_3}{\partial y} & \frac{\partial u_3}{\partial z} \\ u_4 & \frac{\partial u_4}{\partial x} & \frac{\partial u_4}{\partial y} & \frac{\partial u_4}{\partial z} \end{vmatrix} = 0,$$

which follows at once from Euler's theorem that

$$x.\mathrm{col}_2 + y.\mathrm{col}_3 + z.\mathrm{col}_4 = m.\mathrm{col}_1.$$

3. *With the same notation*

$$\left.\begin{aligned} \frac{\partial u_1}{\partial x} v_1 + \frac{\partial u_2}{\partial x} v_2 + \frac{\partial u_3}{\partial x} v_3 + \frac{\partial u_4}{\partial x} v_4 = 0 \\ \frac{\partial u_1}{\partial y} v_1 + \frac{\partial u_2}{\partial y} v_2 + \frac{\partial u_3}{\partial y} v_3 + \frac{\partial u_4}{\partial y} v_4 = 0 \\ \frac{\partial u_1}{\partial z} v_1 + \frac{\partial u_2}{\partial z} v_2 + \frac{\partial u_3}{\partial z} v_3 + \frac{\partial u_4}{\partial z} v_4 = 0 \end{aligned}\right\} \qquad (\beta)$$

This is the same as to say that the determinant of the preceding paragraph continues to vanish when in place of its first column we substitute a repetition of one of the other columns.

4. *With the same notation*

$$\left.\begin{aligned} u_1\frac{\partial v_1}{\partial x}+u_2\frac{\partial v_2}{\partial x}+u_3\frac{\partial v_3}{\partial x}+u_4\frac{\partial v_4}{\partial x}=0 \\ u_1\frac{\partial v_1}{\partial y}+u_2\frac{\partial v_2}{\partial y}+u_3\frac{\partial v_3}{\partial y}+u_4\frac{\partial v_4}{\partial y}=0 \\ u_1\frac{\partial v_1}{\partial z}+u_2\frac{\partial v_2}{\partial z}+u_3\frac{\partial v_3}{\partial z}+u_4\frac{\partial v_4}{\partial z}=0 \end{aligned}\right\}. \qquad (\gamma)$$

Differentiating (α) with respect to one of the independent variables, say x, we have

$$\sum u_h\frac{\partial v_h}{\partial x}+\sum v_h\frac{\partial u_h}{\partial x} = 0,$$

and since, by (β), the second sum here is equal to 0, so also must the first sum.

5. Solving now the equations (γ) for the u's we obtain at once Clebsch's result: in fact (γ) may be viewed as simply another way of saying that the u's are proportional to

$$J(v_2, v_3, v_4), \quad -J(v_1, v_3, v_4), \quad J(v_1, v_2, v_4), \quad -J(v_1, v_2, v_3).$$

6. The next requirement is to explain the cause of the efficacy of Clebsch's irrelevant-looking determinant of the $(n+2)$th order. In doing this we need not confine ourselves to elements that are differential-coefficients: the determinant to be bordered may be any determinant whatever, anything peculiar being introduced along with the border, and indeed with only part of that. Let us take, for example, the general determinant of the fourth order $|a_1b_2c_3d_4|$. The added row of four elements then is

$$e_1, e_2, e_3, e_4$$

where the e's again are any quantities whatever: but the added column is

$$0, \ 0, \ 0, \ m_1d_1+ \ \dots \ +m_4d_4, \quad m_1e_1+ \ \dots \ +m_4e_4:$$

and the new theorem to be established is

$$(\delta) \quad \begin{vmatrix} a_1 & a_2 & a_3 & a_4 & . \\ b_1 & b_2 & b_3 & b_4 & . \\ c_1 & c_2 & c_3 & c_4 & . \\ d_1 & d_2 & d_3 & d_4 & \Sigma md \\ e_1 & e_2 & e_3 & e_4 & \Sigma me \end{vmatrix} = |d_1e_2|.|D_1m_2| + |d_1e_3|.|D_1m_3| + \dots \\ \dots + |d_3e_4|.|D_3m_4|,$$

where D_r is the cofactor of d_r in $|a_1b_2c_3d_4|$.

More proofs than one suggest themselves. That which lends itself most readily to generalization consists in changing the last column into

$$-\Sigma ma, \ -\Sigma mb, \ -\Sigma mc, \ 0, \ 0,$$

and then expanding in terms of the minors formed from the last two rows. Doing this we see that the cofactor of $|d_1 e_2|$

$$= -\begin{vmatrix} a_3 & a_4 & m_1 a_1 + m_2 a_2 \\ b_3 & b_4 & m_1 b_1 + m_2 b_2 \\ c_3 & c_4 & m_1 c_1 + m_2 c_2 \end{vmatrix}$$

$$= -m_1 |a_1 b_3 c_4| - m_2 |a_2 b_3 c_4| = -m_1 D_2 + m_2 D_1$$

$$= |D_1 m_2| ;$$

and similarly with the cofactors of $|d_1 e_3|$, etc.

7. Applying this result to Clebsch's determinant we see that the latter is equal to

$$|a_1 b_2| \cdot |u_1 w_2| + |a_1 b_3| \cdot |u_1 w_3| + \ \dots ;$$

and its equivalent being known to vanish for all values of the a's and b's, it follows that the second factor of every term of it must vanish, and that therefore

$$\frac{u_1}{w_1} = \frac{u_2}{w_2} = \frac{u_3}{w_3} = \ \dots \ .$$

8. The peculiar identity established in §6 is, however, only the first of a series. Thus taking the same basic determinant as before, namely, $|a_1 b_2 c_3 d_4|$, and repeating the process of bordering, we obtain for investigation the determinant

$$\begin{vmatrix} a_1 & a_2 & a_3 & a_4 & \cdot & \cdot \\ b_1 & b_2 & b_3 & b_4 & \cdot & \cdot \\ c_1 & c_2 & c_3 & c_4 & \cdot & \cdot \\ d_1 & d_2 & d_3 & d_4 & \Sigma md & \Sigma nd \\ e_1 & e_2 & e_3 & e_4 & \Sigma me & \Sigma ne \\ f_1 & f_2 & f_3 & f_4 & \Sigma mf & \Sigma nf \end{vmatrix} .$$

Clearly it is equal to

$$\begin{vmatrix} a_1 & a_2 & a_3 & a_4 & \Sigma ma & \Sigma na \\ b_1 & b_2 & b_3 & b_4 & \Sigma mb & \Sigma nb \\ c_1 & c_2 & c_3 & c_4 & \Sigma mc & \Sigma nc \\ d_1 & d_2 & d_3 & d_4 & \cdot & \cdot \\ e_1 & e_2 & e_3 & e_4 & \cdot & \cdot \\ f_1 & f_2 & f_3 & f_4 & \cdot & \cdot \end{vmatrix} ,$$

and in this the cofactor of $|d_1e_2f_3|$ is

$$-\begin{vmatrix} a_4 & m_1a_1+m_2a_2+m_3a_3 & n_1a_1+n_2a_2+n_3a_3 \\ b_4 & m_1b_1+m_2b_2+m_3b_3 & n_1b_1+n_2b_2+n_3b_3 \\ c_4 & m_1c_1+m_2c_2+m_3c_3 & n_1c_1+n_2c_2+n_3c_3 \end{vmatrix},$$

which

$$\begin{aligned} &= \left.\begin{matrix} -|a_4b_1c_2|m_1n_2-|a_4b_1c_3|m_1n_3-|a_4b_2c_1|m_2n_1 \\ -|a_4b_2c_3|m_2n_3-|a_4b_3c_1|m_3n_1-|a_4b_3c_2|m_3n_2 \end{matrix}\right\}, \\ &= D_3m_1n_2-D_2m_1n_3-D_3m_2n_1+D_1m_2n_3+D_2m_3n_1-D_1m_3n_2, \\ &= |D_1m_2n_3|. \end{aligned}$$

Similarly the cofactors of $|d_1e_2f_4|$, $|d_1e_3f_4|$, $|d_2e_3f_4|$ are found to be $|D_1m_2n_4|$, $|D_1m_3n_4|$, $|D_2m_3n_4|$; so that our double-bordered determinant is expressible as a sum of products of pairs of three-line determinants. (ϵ)

9. As this result may be written

$$\left\|\begin{matrix} d_1 & d_2 & d_3 & d_4 \\ e_1 & e_2 & e_3 & e_4 \\ f_1 & f_2 & f_3 & f_4 \end{matrix}\right\| \cdot \left\|\begin{matrix} D_1 & D_2 & D_3 & D_4 \\ m_1 & m_2 & m_3 & m_4 \\ n_1 & n_2 & n_3 & n_4 \end{matrix}\right\|, \qquad (\epsilon')$$

which again by the multiplication-theorem is equal to

$$\begin{vmatrix} |a_1b_2c_3d_4| & \Sigma dm & \Sigma dn \\ |a_1b_2c_3e_4| & \Sigma em & \Sigma en \\ |a_1b_2c_3f_4| & \Sigma fm & \Sigma fn \end{vmatrix}, \qquad (\epsilon'')$$

we observe that we might have begun by expanding the original determinant in terms of the minors formed from the first four columns, and thence proceeded through (ϵ'') and (ϵ') to (ϵ).

ON SOME FOSSIL FISHES FROM THE DIAMOND-BEARING PIPES OF KIMBERLEY.

By R. Broom, M.D.

(Plates XX.–XXII.)

(Received May 26, 1913. Read July 16, 1913.)

The strata surrounding the Kimberley group of mines consist of the upper Dwyka shales, denudation having removed from this area all the higher strata such as are found immediately to the east, between Kimberley and Bloemfontein.

The missing horizons consist of the Ecca beds, that is, of soft blue and greenish shale and flag-stones approximately 2,000 feet thick; and of the succeeding Beaufort beds, characterised by yellow sandstone bands parted by blue and green shales, mud-stones and flag-stones, at least several thousand feet thick.

The *Acrolepis* may have come from either the Dwyka or the Ecca shales, and it is interesting in this connection to note that scales belonging to this genus have been obtained close to the summit of the Ecca shales near Ladysmith, Natal.*

Conspicuous sandstones are not known to occur in the Ecca beds of the northern Cape of Good Hope, and the sandstone inclusions are therefore in all probability from some horizon in the Beaufort beds—a view which is supported both by the fossils described below and by the small endothiodont reptile, *Chelyoposaurus williamsi*, Broom, found in Wesselton Mine.†

The inclusions probably fell down into the pipes and were there preserved while denudation removed all traces of the parent rocks over the locality in question.

* Annals Natal Museum, **2**, 2, 1910, 227 and 229.

† Records Albany Museum, **1**, 3, 1904, **15**, 4, and Trans. S.A. Phil. Soc., **154**, 1905, **259**.

The fishes, as well as the reptile, are now preserved in the McGregor Museum, Kimberley.

Acrolepis addamsi, sp. n.

(Plate XX.)

This species is founded on a number of fragmentary fishes crushed together on a small slab of shaly sandstone found in Wesselton Mine on the 135 ft. level.

Though of the five fishes four are almost certainly the same species, to avoid any possible confusion the largest specimen will be regarded as the type.

Though it is impossible to ascertain the length of the species, we may, I think, safely assume that it was half as large again as the type of *Acrolepis ortholepis*, Traquair, figured by Traquair, and further that the body was relatively deeper.

The dorsal fin consists of about 32 rays, all jointed, and the posterior ones at least branched distally.

The pectoral and pelvic fins are only seen on a smaller specimen, which may possibly not be the same species, and to avoid confusion I think it better to leave out the description.

The anal fin is very large and powerful and has about 55 rays. All are jointed and mostly bifurcated.

The caudal fin is large and bifurcated, but not very deeply. The rays are very numerous and distally branched. Fulcra are present along the lower border. A series of long narrow median scales form the upper ridge.

The scales of the middle of the body have a series of flat ridges passing obliquely backwards and anastomosing. The posterior border of the scales is denticulated with about 6 or 7 blunt serrations. The scales are quite unlike that figured by Smith Woodward as the type of *Acrolepis digitata*.

I have pleasure in dedicating this species to Mr. C. E. Addams, sometime manager of Wesselton Mine.

Disichthys kimberleyensis, g. et sp. n.

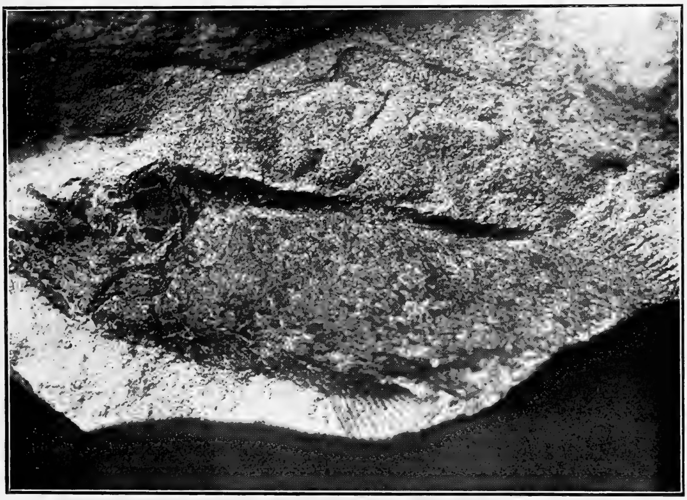
(Plate XXI.)

The type of this new genus and species is one of 6 or 7 fossil fishes on a slab of soft sandstone found in the De Beers Mine tip.

The fishes represent three different species, of which two are sufficiently well preserved for description. Both are very distinct new types, and must be placed, in my opinion, in new genera.

Acrolepis addamsi, *Broom.* × 3/2

1. Disichthys kimberleyensis, *Broom*. Life size.



2. Disichthys kimberleyensis, *Broom*. × $\frac{6}{5}$. West, Newman.

West, Newman.

PELEICHTHYS KIMBERLEYENSIS, *Broom.* $\times \frac{3}{2}$ nearly.

The first of the two which I name *Disichthys kimberleyensis* is a small palæoniscid, which at first sight one might be inclined to refer to *Cycloptychius* or *Rhadinichthys*, but on close examination it is found to differ too greatly to be even provisionally placed in either.

The type measures about 120 mm. in length, and the greatest depth of the body is 25 mm. The dorsal fin is placed well back, commencing at 62 mm. from the snout, and the anal commences only a short distance further back, viz., 64 mm. from the snout.

A second imperfect specimen is of larger size, measuring probably 135 mm. in length and a body depth of 30 mm.

The skull is palæoniscid, with the suspensorium vertical and the gape small. The operculum is almost square. In both maxilla and mandible the teeth are small, uniform and pointed.

The dorsal fin is situated well back and wholly behind the middle plane. It has about 26 rays, of which the first five are short, gradually lengthening to the sixth. All are jointed and undivided even at their tips.

The pectoral fin is not well preserved in any specimen, but the rays are certainly undivided.

The pelvic fin has 18 undivided rays.

The anal fin much resembles the dorsal. It has about 20 undivided rays.

The caudal fin is imperfectly preserved, but pretty certainly it is not bifurcated, the axis of the body being directly continuous into the axis of the tail as in *Holurus*. The lower side of the tail axis has a series of undivided rays.

The scales are of moderate size, but thin and rounded as in *Cycloptychius*. They are feebly ornamented with numerous small ridges running backwards.

Of known forms *Disichthys* comes nearest to *Holurus*.

Peleichthys kimberleyensis, g. et sp. n.

(Plate XXII.)

This new genus and species is founded on a single specimen on a slab of sandstone from the De Beers Mine tip very similar in texture to that in which *Disichthys* was met with. Unfortunately this unique specimen is in a rather unsatisfactory condition. The head and neck are represented by only a few impressions, and the fins and tail are not very well preserved.

Though probably belonging to the same group as *Disichthys*, it cannot, I think, be placed in that genus.

The total length of the fish is about 80 mm., and the greatest body depth 14 mm.

The dorsal fin is as in *Disichthys kimberleyensis* entirely behind the middle point of the body, and it further resembles it in being apparently made up of unbranched rays. It differs, however, in having a very much larger number of rays—probably 40—which are feeble, and in thus having a very much larger base for the fin.

The pectoral fin is not preserved, but the pelvic fin is in fair condition. It is small and situated a little in front of the origin of the dorsal.

The anal fin is of moderate size and triangular. It is mainly behind the dorsal instead of practically opposite it as in *Disichthys kimberleyensis*. It is composed of about 28 rays, of which the first few are short.

The caudal fin appears to be bifurcate, though in the specimen the under lobe is pushed against the main axis. The rays are numerous, small, and unbranched.

The scales differ from those in *Disichthys* in being rhombic and thicker. They are ornamented by ridges running parallel to the posterior edges of the scales.

ROYAL SOCIETY OF SOUTH AFRICA.

PRESIDENT'S ADDRESS.

By L. PÉRINGUEY, D.Sc., F.Z.S., F.E.S., &c.

THE ANTIQUITY OF MAN.

Introduction.

I had at first thought to give you to-night a retrospect of what is known of the lithic industry, or stone implement-making, in South Africa, and its bearing towards not only the Antiquity of Man in this part of the world, but also to the antiquity of a certain native race of which a few pure-bred individuals only are now left, namely the Bushman.

I find it, however, impossible to condense the information on record in an address, nor would it be possible to bring out my points to your notice without a long series of lantern slides. I propose therefore to restrict myself to a résumé of the present knowledge of the antiquity of man. During the last fifteen years discoveries of such importance have occurred that the prehistorian is now fronted with tangible facts, where a few years back he had to be satisfied with hypotheses. Let it be said at once that several of these hypotheses have been justified by the newly discovered facts. On the other hand, certain doctrines which were considered as firmly established are at present seriously assailed.

I shall now proceed to explain broadly the stages or divisions during which man produced artefacts in the shape of stone implements, relics of his skill that led not only to his being discovered, but allowed us to follow his increasing mental development before his skeleton was brought to light.

These stages are: the Mesvinian or Strepyan, still very much discussed; the Chellean and Acheulean forming the Lower Palaeolithic; the Mousterian, or Middle Palaeolithic; and the Aurignacian, Solutrian, and Magdalenian, all three belonging to the Upper Palaeolithic.

The reasons for these divisions are as follows: In the Chellean, Europe was a warm country with a mild and damp climate. The fauna was characterised by the presence of the Hippopotamus and the *Rhinoceros mercki* (the nearest ally of our White Rhinoceros), and *Elephas Antiquus,* which is a nearer ally to the Indian than to the present African form.

The Acheulean, which follows, is closely connected with the Chellean. In most places the fauna is still that of a warm country, but in certain localities arcto-alpine forms belonging to the next stage are also in evidence. The stone implement, the "boucher," * predominates still, but it is of finer workmanship and is a more efficient tool.

During the Mousterian or Middle Palaeolithic the temperature was lower and the fauna was that of a cold, moist climate. The Mammoth, an animal of 16 or 18 feet in height, takes the place of its still larger predecessor *Elephas Antiquus*; with it is a woolly Rhinoceros, *Rhinoceros tichorrhinus.* The Acheulean boucher is still occasionally, but seldom, met with. The Mousterian implement is usually chipped on one face only, the reverse side shows well-nigh invariably the convex node called "bulb of percussion"; the edges of the implements are often carefully retouched; the flakes, obtained as a by-product, are used again for smaller tools, &c. It is in the Middle Palaeolithic that the Neanderthal type of man has been found.

The classification of the three Upper Palaeolithic stages is a very difficult one. In the Aurignacian Age the cold fauna of the Mousterian has gone, and its representatives are very much reduced in number. An amelioration of climate has evidently taken place. Man has so much progressed mentally or by contact that the implements are distinguished by a variety of forms; bone is being used.

In the Solutrian the climate is no longer as mild as it was in the Aurignacian; implements of stone are being made for newly developed requirements; bone and ivory are in common use.

In the Magdalenian Age, the lowering of temperature becomes a dry cold which makes itself keenly felt. This last division is characterised by the use of the Reindeer horn.

During these three periods the severity of the climate, especially in winter, induced man to seek shelter to avoid partly its rigour. This shelter he found in the caves or grottoes formed naturally in calcareous formations or under hanging rocks. His mental faculties were taxed to the utmost to resist the *ferae naturae* which became more and more numerous (but he did this much more likely by craft than by brute force), and also to obtain from them food, and garments as protection from the cold. How long did these three periods, called the period of the Reindeer, last, or by what interval were they separated is still an unsolved problem; but

* The "boucher" corresponds to the "celt." The term, proposed by Sollas, should be adopted.

it is in the Aurignacian Age that slender, even delicate tools of ivory and bone make their appearance ; stone lance-heads admirably worked on each side, arrow-heads with peduncles, bodkins, saws, &c., are testimony to man's increasing industry and skill.

Not only had by now the sense of art arisen in him, but he expressed it in frescoes of admirable colouration, in sculptures on ivory or stone, in gravings, petroglyphs, and glyptics which are only equalled by those of another living race, the name of which you have already in your mind, namely, the Bushman.

There is not going to be anything very new about this exposé of the antiquity of man, except that it is nearly up to date, but it is a preliminary attempt to try and co-relate, if possible, the Palaeolithic Stone Age of Southern Africa with that of Europe and of part of Asia.

Unfortunately the most important element in the chronology of the European divisions, namely, the Great Ice Age, is totally wanting in South Africa. There the "genial episode" the "period of advance," the "glacial episode" and the "period of retreat,"—these four parts of the oscillation of climate of the third and fourth glacial epochs which have played such a rôle in the succession of faunas and of implements in the North, cannot be of any assistance to us in the South. It may therefore be assumed that the Pleistocene epoch in South Africa has not altered much the land features, and that the temperature or climate has been, from the inception of this period little different from what it is to-day.

And on that account is, in my opinion, explained the contemporaneity here of the Chellean, Acheulean, Mousterian, and Aurignacian lithic forms, a fact which can no more be doubted than the survival of these forms until comparatively a few years back.

The Eoliths.

It is obvious that the stone industry must have had a beginning, and that an almond-shaped boucher was not evolved by the hand of primitive man in the finished state represented by this Saint Acheul boucher of flint, or this Stellenbosch boucher of quartzite, now before you.

That there must have been a graduation from the accidental sharp-pointed or sharp-edged flake, which to me is a matter of faith, to the carefully trimmed amygdaloid tools I am showing you is to man's mind, trained at all events as our mind is now, equally obvious.

Working, therefore, on this inductive method, certain prehistorians have tried to find in more or less amorphous flints or partially split nodules of flint the predecessor of the boucher or racloir of the Palaeolithic type in position on geological horizons which would throw back the antiquity of man to the Oligocene (if not the Eocene) and the Upper Miocene, thereby endowing Anthropomorphous Apes—at least so they must be considered in the light of our present Palaeontological knowledge —with the cunning necessary for the production of artefacts, the utility to them of which has also never been clearly explained.

I may state at present that all these so-called precursors of the lithic industry are invariably made of flint, and of no other hard material such as quartzite, indurated shale, basalt or hard volcanic rocks, or quartz, materials of which the majority of our South African implements consist. This is a point of great importance.

It was in 1867, not very long, therefore, after Boucher de Perthes' interpretation of the human artefacts found in the Somme Valley (France) had been accepted as valid (namely, that there existed in Europe a race of men contemporaneous with the Reindeer and the Mammoth, that fashioned weapons and tools out of "rognons de silex" nodules of flint) that the problem of the Tertiary man was introduced by the discovery of flints at Thenay, in beds of the Upper Oligocene, at the dawn of the Miocene. That is to say, if these implements were accepted as artefacts it would prove that the makers were contemporaries of the *Anthracotherium*, a pachyderm older than the Mastodon, an ancestor, but not the first, of the Elephant. To solve the difficulty, a very obvious one, G. de Mortillet suggested that the maker might be an Anthropoid Ape, somewhat like *Dryopithecus*, found in the Miocene of the geologists. But it is now generally accepted that neither *Dryopithecus* nor *Palaeopithecus*, from Siwalik, belong to the human phylum.

Ten years later (1877) were found at Aurillac, also in France, numerous flints which have undoubtedly the appearance of artefacts. The geological horizon of this locality is undoubtedly that of Upper Miocene Age; and the makers of these artefacts, were they such, would have lived with the *Dinotherium giganteum*, the first horse, *Hipparion gracille*, the sabre-tooth tiger, *Machairodus*, &c. There again to solve the difficulty, a hypothetical man-monkey or monkey-man is invented by Mortillet, to serve as an explanation, namely, *Homosimius ramesi*. From that time war began to rage between these archaeologists, who, ascribing these artefacts to man, relegated him to the Miocene, and those who saw only in the so-called "silex tertiaires" flint nodules washed from the upper layers and broken by the waters of the Tortonian river. Subsidence of deposits, great variation of temperature, and especially frost, producing the well-known "éclatement" or splitting of nodules which are not necessarily completely homogenous, and other causes, of which violent natural shock or projection against an equally hard body may prove to have been a most important one, such, according to these adversaries of Miocene man, are the causes which produced the artefact appearance of the Thenay flints. Similar discoveries followed in the valley of the Tagus, in 1871; the horizon being a little more recent than that of the Thenay, and characterised also by the presence of the *Hipparion*, the ancestor of the horse, &c.

In 1899 Mr. B. Harrison brought to the notice of antiquarians the famous "plateau implements" found in gravels capping the high plateau of Kent. That this plateau is very ancient is admitted by all; it is lying at a higher level than any of the existing terraces. By some the deposits are looked upon as pre-glacial, by others as belonging to the Pliocene. The term "eolith" was invented for these very amorphous flints, and the controversy about their having been artificially dressed, or having come to their present form by natural agencies has not yet ceased, although its heat greatly cooled down when M. M. Boule, who it must be said, in fairness, always opposed the theory of the eoliths of Aurillac and Thenay, showed pretty conclusively that mechanical agents do easily and naturally transform flint nodules into "eoliths." His demonstration appeared in "L'Anthropologie," 1905, and can be summed up as follows:—

At Guervilles, near Mantes (France), is a factory where cement is prepared by means of rotary machines moving in a tub filled with chalk and plastic clay. When the process is over the fragments of flint left in the residue exhibit all the shapes and forms claimed to be artefacts by the partisans of the eolithic doctrine. Not only are the "crescent-shaped," "hollow-end," "horse-shoe" scrapers of the Kent eoliths, or of the Oligocene of certain parts of Belgium reproduced, but also—and this is perhaps more important—rough scrapers of the Magdalenian type, and some with a Neolithic facies. The speed of the water at the periphery of the vats was found to be only four metres a second, a speed that cannot compare with that of the large European rivers in flood. It is a matter of knowledge, or at least accepted as such, that the torrential floods of to-day cannot also compare with the torrential forces of the Quaternary (Pleistocene) rivers.

I have given elsewhere my reasons for not accepting the alleged eolithic theory with regard to some water-worn quartzitic examples from Pretoria, but I may here give my experience of the implements of a siliceous texture (chalcedony) occurring at or near the Victoria Falls, where this material prevailed: at least I found no other.

Among many crescent-shaped, undoubted tools, worn by the attrition of sand, which has now disappeared, to the great surprise of my companion, Mr. Maufe, of the Rhodesian Geological Survey, in whose company I was, we found several nuclei of large size, and also circular, disc-like pieces, of not much thickness and certainly not exhibiting the famous "bulb of concussion" in which I still believe. My companion exclaimed, "These are split by the sun-heat." I had come to this conclusion an hour before, as I was groping my way among the two surface deposits we encountered. Maufe was looking for the geological features. I was interested in the lithic industry.

Now chert, whether chalcedony or under any other name, is a siliceous formation, just like flint, only that the latter is an accumulation of silica round an organic remain, whereas the latter is not, but the texture is nearly alike; and the influence of natural causes—heat in the present case, frost in that of the European or Palaearctic region—had produced an effect nearly similar, but not quite identical all the same, because discoidal pieces are extremely rare in European Palaeoliths or Neoliths. Moreover, crescent-shaped pieces (the *pièces à encoche* of the French) are there quite common, and were it not that real artefacts were found together, as testified by these not easily expressed minutiae which seldom lure the trained archaeologist from the path of orthodox righteousness, one might have felt inclined to imagine he had discovered a new site of Kent Plateau implements.

If we now recapitulate the details of the question of the so-called eoliths we shall find that the then numerous, but now greatly reduced, believers in the authenticity of these artefacts found in remote times known to geologists as, if not Eocene proper (the dawn of recent times), at least Oligocene, Miocene, and Pliocene horizons or formations, had to call in support of their theory the existence of these geological times of Anthropomorphous Apes, or Simian-like men.

No one now pays much attention to the hypothetical presence of a semi-human precursor, *Homosimius*, to explain the Oligocene "flints," and the once-invoked *Dryopithecus* (a monkey of the Middle Miocene, the remnants of which were found not very far from the Thenay and Aurillac "flints"), is now, as stated before, not only excluded from the genealogy of the human race, but is considered to be very inferior to some of the present apes.

But the theory of the Simian origin of man was still being entertained by palaeontologically minded antiquarians, when in 1894 Dr. Dubois, a Dutch Palaeontologist, unearthed at Trinil, in the island of Java, the remains, unfortunately very incomplete, of an animal to which he gave the name of *Pithecanthropus*, or monkey-man, which, according to him, was the missing link said to have been announced by Darwin, although I cannot find the latter ever said so in formal terms, and hinted at, it is also said, by Lamarck, although there also I cannot find evidence of the proposition.

It is somewhat unfortunate that more remnants of the *Pithecanthropus* have not been found as yet; and its position in the scale of humanity is certainly not accepted by all competent men as Dr. Eugène Dubois would have liked. Referred at first to the Pliocene, leading us thus to the mythical but long-invoked Tertiary man, it is now relegated on good authority to the Lower Quaternary, the beginning at the Pleistocene. Is this fossil of human or simian nature? Is it bridging the interval between man and anthropoids? A storm of controversy has arisen on this question. There are those who consider it a human ancestor, but not quite human; others as of truly human nature; others again as a large *Hylobates*, and if such, it is a member of the Simiidae, and therefore a true ape. Duckworth comes to the conclusion that *Pithecanthropus erectus* "was an anthropoid ape of a degree of cephalisation far superior to any ape now existing; and that in it we possess the nearest likeness yet found of the human ancestor." He agrees that the Trinil fossil was of a stature rather over the average. Keith, however, goes further, and not only does he believe *Pithecanthropus* to be as old as the Pliocene of Europe, or early Pleistocene, but he adds "the characters of the femur leave no doubt, in spite of minor peculiar features, that the fossil man of Java was completely adapted for erect posture and erect progression as the man of to-day. There are no features in it which suggest the slouching gait of Neanderthal man." This is perhaps too affirmative a statement with regard to the latter, as we shall see later on. The few pieces found are the calvaria (upper portion of the skull), a femur (thigh-bone), and three teeth. The femur is sufficiently like the human bone for Virchow's affirmation that this thigh-bone does not belong to the same individual to whom the calvaria does; the first is that of a man, the second is that of an ape.

It should be remembered, however, that the same Virchow decided that the calvaria of the Neanderthal man was that of a human idiot; that Huxley was very careful not to express his opinion, and that Broca, of all anthropologists of repute, was the only one who, at the time, asserted that this portion of the skull belonged to a primitive man, but a man for all that, and not an ape or an idiot.

A new light has been thrown on the phylogeny of the apes by the discovery in the Lower Tertiary of the Fayoum, in Egypt, probably Oligocene, of several forms of true apes, among which one, called by Schlosser *Propliopithecus*, which does really seem to represent an Anthropomorphic Ape; leading, according to him, to the following evolutive filiation.

Propliopithecus, *Pliopithecus*, *Hylobates*, *Dryopithecus*, *Troglodytes*, *Simia*, *Gorilla*, *Homo*, with whom *Pithecantropus*, on characters taken from the jaw (although three teeth are only known), this author considers should mingle.

And thus we are brought back to the contentious Oligocene flints of Thenay, Aurillac, Cromer Forest, Boncelles, &c., &c. Unfortunately for those who hold to the artefact character of these flints, the Oligocene ancestor of man would not have been physically able to chip flints, for its size was almost that of a newly-born baby. Even *Anthropodus* of the Lower Pliocene—which Schlosser does not, however, place in his genealogical list, perhaps because only a tooth of the animal is known —could have hardly exceeded the size of a twelve-year-old child.

Keith, however, ascribes to *Pithecantropus* a height of 5 feet 6 inches. According to Boule the average size of the men of Neanderthal type is 1 m. 58 c., or 5 feet 2 inches.

But before coming to that Neanderthal man, to whom I have found it necessary to allude twice, it is necessary to mention what has been dubbed the "Iconian" stone industry.

Lately there has been found in a bed which is the undisturbed base of the Red Crag, near Ipswich, in Suffolk, flints which the finder, Mr. R. Moir, alleges have been worked by man. They were found in hollows on an eroded surface of London Clay; and it seems indisputable that this bed in which the flints occur is the undisturbed base of the Red Crag. But it is disputable if these flint implements are artefacts, or whether they come in again in the category of "eoliths." Professor Ray Lankester, in a well-illustrated memoir just published in the TRANSACTIONS of the Royal Society, maintains that they are the fabrication of man. They are mostly of what he calls the "eagle-beak or rostro-carinate" type, and possess a form differing entirely from that of any other Palaeolith. He accounts for the glacial scratchings on the implements found by Moir by the conclusion that the basal deposit of the Red Crag is subsequent to the glaciation of the land surface. The "men who made the Sub-Crag implements existed on an extensive land surface which touched the sea-line at a spot which is now Suffolk. Probably they were there during a period of mild climate coincident with the deposit of the Coralline crag. The bed in which the implements are found was probably deposited in quite shallow water, the flints being carried in and deposited by ice. The implements characterise a phase of development earlier than any hitherto known by equally indisputable evidence."

It is not necessary to discuss here the arguments adduced by Messrs. Moir and Ray-Lankester. It might be urged that many of the specimens affect forms of the Thenay and Aurillac eoliths; that the peculiar "rostro-carinate" shape may be caused by a fault (chink or crevice) in the nucleus; that the striae considered as of glacial origin, might have been produced by the displacement of sand particles on the surface of the flint, as now occurs in geological beds exposed to strong pressure; also that remaniements of that part of the bed are quite possible.

But to me, the main point of importance is that Ray Lankester would bring the Red Crag forward from the Pliocene to the Pleistocene, to make them fit in, I presume, with the lithic culture of the genus *Homo.*

Whether it will be found equally convenient to rejuvenate the horizons of Thenay, and Aurillac, among others for the place usually assigned to them, namely, Upper Oligocene and Upper Miocene, respectively, is another matter. In a postscript to the said memoir, Ray Lankester mentions worked flints that have been found resting on Eocene Clay, upon the seashore of Selsea Bill, Sussex; and also of rostro-carinate implements near the deposit of Aurillac, already alluded to. This leads him to state that "there is a good deal of evidence leading one to entertain, at any rate, as a hypothesis to be further tested—the possibility of a community of origin of the Icenian, the Ighthamian and the Aurillacian industries. But if Lankester is right in his removal of the Pliocene Red Crag into the Pleistocene because of the implements found there, man's industry would have proven even more useful for Geology than his skeleton.

We ought to have soon some better proofs than those obtained from flints that may or may not be artefacts, because Reid Moir and Keith have discovered at Ipswich a skeleton which they said represented pre-Boulder Clay man—the said skeleton is said to have been found in glacial sand underlying Boulder Clay; and the publication of a memoir by Smith Woodward, on a skeleton found in the same horizon as the Kent Plateau Eoliths is announced. It is therefore wise to wait for these forthcoming accounts. Keith, however, says that the Ipswich man differed both from the Heidelberg man and the Java man, and "in every point in which he differs from them he approaches modern man." This statement is, a priori, not very reassuring.

The Palaeoliths.

Let us now see what this Heidelberg man is. This earliest trace of Neanderthal type of man was discovered in the valley of Neckar, a few miles above the university town of Heidelberg. It was found in the sands of the Mauer, some three miles and a half from the river. These sands, it is alleged, were laid down in the bed of the ancient river soon after the Pleistocene began. Bones and teeth of an extinct rhinoceros, and of a kind of horse, *Equus stenonis*, were found in the same layers, and it is stated that the beds are deeper and much older than the glacial Boulder Clay. It is therefore claimed that the sands were laid down near the beginning of the Pleistocene, or Upper Pliocene. Many people are rather sceptical, however, about the authenticity given to this deposit, and Sollas very justly remarks that the existence of a horse allied to *Equus stenonis* represented at Chelles itself, can no longer be cited in favour of the Pliocene Age of the Heidelberg jaw. Now, in shape and size the Heidelberg mandible shows a condition intermediate to the Anthropoid and the modern human forms. According to Keith "the anthropoid jaw is the primitive one; the mandible is framed to serve the purpose of mastication;

the mandible of modern man is modified to serve in speech." The Heidelberg discovery was made in 1907; but as far back as 1856 the famous Neanderthal skeleton had been discovered; unfortunately it was very much injured, but the calvaria, or skull-cap, was preserved. So long as this discovery remained single, it could not be adduced as convincing; fortunately other finds of similar nature were made, showing similar peculiarities. To these the name of Neanderthal, or Mousterian, man has been given; and the most complete monogram, that of the man of the "Chapelle aux Saints" has just appeared.

I am happy to exhibit to-night one of the first casts of this famous skull, which I owe to the kindness of Professor M. Boule, of the Paris Museum, whose definition I give here verbatim.

"The general facies of the men of the Neanderthal type, as revealed by the most important discoveries made till now can be defined as follows: An enormous head supported by a thick, short trunk, the limbs short, muscular, and very robust. The proportions of the limbs coincide with those of the present human races. The only trait of the general appearance which might be considered as pithecoid would be the enormous size of the head in proportion to that of the body. In any case the *Homo Neanderthalensis* had absolutely, as well as relatively, the largest head known in the genus *Homo*."

The body was found in a grotto, lying on the back. The right arm was bent, the hand drawn towards the head, the left one was extended. The legs were drawn in, resting on the right. Above the head had been placed three or four fragments or ribs (os longum) and parts of the leg of a bovine ruminant, pointing that it had been laid there intentionally, perhaps as food for the defunct. Round this body were numerous flakes of quartz, flints, some of them, well worked, and all of the typical Mousterian form; fragments of ochre, broken bones, &c.

This grotto, according to the discoverers, men well versed in spelean research, should be looked upon not as a dwelling, but as a place of burial, where many funeral feasts had been held.

This skeleton is that of an adult about fifty years old.

That of a youth of about sixteen years of age, and of the same type, was found in the classical deposit of Le Moustier, and if I cite him, it is because it is said of the skeleton: "The posture is that of repose with the face turned to the right, the right arm is under the head, which is surrounded by flint flakes. Besides the skeleton were found, in addition to the flint implements of the Mousterian type some of the Acheulean, among them a *splendidly-worked hand-wedge.*"

I shall now pass over the Cro-Magnon and other types of *Homo Sapiens* to come to the evidence afforded by the lithic industry of South Africa towards the antiquity of man.

Hitherto no human remains have been discovered that could go to substantiate the presence in South Africa of a Middle Palaeolithic man belonging to the Neanderthal race.

But we have his tools in abundance. The shape of these tools, bouchers and scrapers, is identical in spite of difference in the material, whether of flint or not; and the quartzitic implements of the Pyrénées, ascribed to the Middle Palaeolithic, cannot be distinguished from our quartzitic ones.

It is indeed difficult to accept the proposition that the amygdaloidal boucher has originated simultaneously as a well-finished tool in Europe, Africa, Asia, America. (It has not been met with in Australia.)

But if we adopt the theory of intercourse through migration, its presence in lands so very far distant is to some extent expiained.

These migrations are the more probable in that the climatic conditions of the Pleistocene before the advent of the great ice sheet, in Northern Europe, Asia, and America, could not have proved an obstacle.

Let us examine rapidly the evidence of these climatic conditions as a possible key to this intercourse. South Africa is one of the few parts of the world known to offer no indication of a Pleistocene glaciation.

Diligent search has been made for it by three geological surveys, Cape, Transvaal, Southern Rhodesia; all three have failed to find traces of its existence. Thus the Great Ice Age has affected the whole world, even the tropics in part, except South Africa, and perhaps part of Central Africa. It brought in its train conditions which have not failed to influence the animals, and also the man of the period, were it only by the considerable lowering of temperature. The large short-haired animals of the Chellean were gradually replaced by other large animals with thick shaggy hair suitable for an Arctic or semi-Arctic climate for at least a part of the year.

No such thing took place in Southern or Central Africa, where it can safely be assumed that the climatic conditions were the same as they are to-day, and differed little from those of the Chellean period in Europe, &c., as shown by the fauna of this period. Thus, the migrant early-Palaeolithic man proceeding from the South would find, even in parts of England, identical climatic conditions and would meet there some, if not most, of the animals he knew. And the same can be said of the Northern Chellean man if he proceeded South.

Later on, however, climatic changes began to oppose barriers to the continuation of this probably intermittent intercourse, if we accept the evidence of the lithic industry. During the Mousterian with its cold, moist climate the Chellean-Acheulean boucher is no longer manufactured, and if examples are found still in use, as in the case of the "Le Moustier" Middle Palaeolithic man, they appear to have been so highly valued as to have been interred with the body of the owner. The trimming of the Mousterian boucher is poor, as if intended to satisfy merely a passing want. That art of any kind, industrial or other, seems to reach an apogee and then declines until it learns to develop into a new but different direction is a truism among antiquarians, whether prehistorians or not. In this case I deem the retrogression in the lithic industry to be due to the want of continuance in intercourse.

In South Africa, however, the execution remains not only what it was in the earlier days, as shown by specimens found in the most ancient deposits, but the two industries are, and remain contemporaneous, that is to say the finished Chellean and unfinished Mousterian are found side by side, and sometimes also mingled with the Aurignacian type.

It is, of course, a matter of speculation if the evolution of the amygdaloid boucher, with its concomitants, sharp spalls, scrapers, flakes, &c., emanated in the Palaearctic region or in South Africa. But the incredible number of these tools or weapons in South Africa, and north of it, seems to imply that if it did not originate here it was in use among a population much more dense in all likelihood than that of the Middle Palaeolithic of Europe. As for the connection of a part of our lithic industry with the Aurignacian-Solutrian types of the Upper Palaeolithic, the evidence is no longer speculative. But this contemporaneity of the Chellean and Mousterian forms of bouchers point to the evolution of the boucher in South or Central Africa, and postulates therefore for its maker a greater antiquity than that of Le Moustier's Neanderthal man.

If we now leave for a time the purely lithological side of the subject of the Antiquity of Man in South Africa, and we turn to the palaeontological as corroborative evidence, then disappointment awaits us, mostly because the large animals of the early Pleistocene, even of the Pliocene are still with us, and thus afford no help in the unravelling of the implements occasionally found with their remains.

But lately two extinct Antelopes, a *Connochaetes* and a *Cobus* * (Gnu and Pallah-like creatures) have been discovered in the Free State with large flakes and other implements of Palaeolithic type. With these were the remains of *Bubalus baini*, an extinct buffalo, the remains of which had previously been found in a probably later deposit, together with an also extinct horse, &c.

More important, however, than these finds may possibly be that of several molar teeth of a Mastodon found in the Vaal River gravels, which if they were proved to be contemporaneous with the numerous palaeoliths occurring with them, would greatly prolong the antiquity of man. But it is quite possible, however, for this Mastodon to have lasted longer in South

* Fossil Antelopes, referred to *Cobus* or allied to it occur in the Pliocene of India and Lower Pliocene of Attica.

Africa or Africa than it did in Europe, where it does not go beyond the limit of the Pleistocene, whereas in North and South America it survived during the Pleistocene period. A corroboration of this hypothesis is to be found in the fact that these teeth are those of the *Bunolophon* group of the genus Mastodon in which the North African species are included.

Here, however, the lithic industry will again prove of avail. This is one of man's artefacts, a hand-wedge, from Windsorton, found in numbers almost without end, in the very gravels I am speaking of. See how pitted the surface is, how worn the flaked edges. Yet, when broken in two not only does it show that the original texture of the rock or round boulder from which it was "knapped" was not naturally pitted, but you will notice round the periphery a conspicuous zone of weathering or disintegration amounting to nearly one-fifth of the diameter. This is indeed an important piece of evidence: one that makes quite possible the acceptance of the contemporaneity of man with the Mastodon in South Africa, and thereby establishing for *Homo*, whether *neanderthalensis*, or *sapiens*, the greatest antiquity yet attributed to him.

And here evidence of this kind can be repeated *ad infinitum*. Here are large flakes and small flakes from East London made of the same material as that of the hand-wedges or amygdaloid bouĉhers from Windsorton. When broken in two they exhibit the same process of weathering. Unlike the Windsorton implements these have probably never been under water; the process of decomposition, if the term is permissible, is the same, even more intensified. It is with large flakes of this type that the two extinct Antelopes already alluded to were found.

No evidence of the great antiquity of man in South Africa could be more conclusive than that offered by this man's artefacts.

CORRIGENDA.

P. 33, after second line *add Trigon schreineri*, n. sp.

P. 109, line 7, *instead of* "the Woodbush" *read* about 4 miles West of Woodbush village, at the top of a barren hill.

Pl. VII., figures 1 and 2, *instead of* "$\times \frac{2}{3}$," *correct to* $\times \frac{5}{4}$.
figures 3 and 4, *instead of* "Nat. size," *correct to* $\times$ 2.

P. 139, line 28, *instead of* "*Coryphella, Rufibranchialis*," *read Coryphella rufibranchialis.*
line 29, *instead of* "*Marionia, quadrilatera*," *read Marionia quadrilatera.*

MINUTES OF PROCEEDINGS

OF THE

ROYAL SOCIETY OF SOUTH AFRICA.

Ordinary Monthly Meeting.

March 20, 1912.

The President, S. S. Hough, F.R.S., was in the Chair.

Nominations for Membership: Dr. De Wet, Pretoria, by T. H. le Roux and L. Péringuey; A. C. L. Lloyd, Cape Town, by J. C. Beattie and L. Péringuey.

Election: D. Sutherns, Durban.

The President announced the nominations for the new Council, to be elected at the Anniversary Meeting on April 17, 1912: President, L. Péringuey; Honorary General Secretary, J. C. Beattie; Honorary Treasurer, L. Crawford; Members, H. Bohle, J. K. E. Halm, R. T. A. Innes, C. F. Juritz, R. A. Lehfeld, R. Marloth, E. T. Mellor, H. H. W. Pearson, A. Theiler.

Communications:—

"Bushman Sticks decorated on Intaglio and Poker-work, a Note on the Decorative Skill of the Bush People and other Aborigines," by L. Péringuey.

Specimens of sticks, decorated with drawings, and carvings, also busts and models, etc., were exhibited. On the sticks the intaglios were extremely fine, and represented hunting scenes, in which men in police uniform and on horseback were depicted with most consummate skill; other sticks were ornamented with poker-work and line drawings of very great artistic merit, but representing modern subjects, a railway train among them. Poker-work was, in his opinion, probably of Kaffir origin, and it was quite possible that the Bush people had obtained it from the latter, but improved on it through their natural artistic disposition. He had at one time doubted the authorship of rock-graving in connection with the Bush people, but he exhibited a Bush painting, in which the back of the animals had been graved. The Bushman thus combined the two arts, graving and painting. An excellent instance of pictograph was shown in the shape of a snuff-gourd, decorated by an emissary of the Zulu Chief Dingaan, but who, however, died on his return journey, and in which were executed, in line poker-work, the most memorable things the envoy had noticed in Cape Town: a Dutch house, with its quaint gable ; a posse of cavalry and Government soldiers entering the gates of the Castle; a Boer wagon; gentlemen on horseback; sportsmen firing at birds, with the pointer dog at attention; the face of the large clock of the Dutch Reformed Church, and, lastly, a man with a very tall hat on playing the organ. The explanation of this pictograph is obvious. The Zulu could not have made his master understand things so extraordinary but by means of a delineation of the same. The question was further discussed of how far Bushmen drawings and carvings were to be looked upon as records of events, or as the expression of artistic skill *per se;* instances applying to the two hypotheses being quoted in turn.

"On some Meteorological Conditions controlling Nocturnal Radiation," by J. R. Sutton.

This paper contains the results of some hourly observations of radiation temperature made between sunset and midnight with two spirit thermometers, one lying upon, and the other supported on a stand five inches above a grass lawn; with a discussion of the meteorological conditions that determine the differences of their readings. According to the results obtained, it appears that after allowance has been made for the state of the sky and the movement of the air, the only factor of real importance determining the radiation temperature gradient is the relative humidity.

"The Resultant of a Set of Homogeneous Lineo-linear Equations," by Thomas Muir.

Three different methods are given for obtaining the resultant, but the main interest is concentrated on one of them, because of two or three somewhat obscure references made to it by Sylvester when studying the problem in 1863. Although Sylvester in one passage spoke of his researches as having been successful, and in another gave utterance to the most extravagant hopes regarding the fruitfulness of his result, he nevertheless did not proceed to publication, and after the year mentioned never once referred to the subject. The problem has also an interesting connection with bipartite functions.

"On the Variation in the Value of the Atmospheric Electrical Potential with the Altitude," by W. A. Douglas Rudge.

This paper gives some account of observations taken at various places in South Africa in order to find the relation which exists between the atmospheric potential gradient and the altitude of the places of observation. Observations were taken between Lourenco Marques and Durban, via Johannesburg, passing thus from sea-level to sea-level over a considerable stretch of country in which the altitudes rose to nearly 7,000 feet. A Wilson pattern electrometer was used, the collecting-plate being coated with radium. The electroscope had previously been calibrated by a number of storage cells, and potentials up to 500 volts could be measured.

The general result is that there is a great change in the value of the potential gradient with the altitude, the extreme value at the highest point (6,500 feet) being not more than one-eighth of that at sea-level. Similar differences having been observed on previous occasions at other places, led to the investigations being conducted. The maximum values were about 500 volts per metre at Lourenco Marques and Durban, and 58 volts at Belfast, 6,500 feet above sea-level, and at places in between values were obtained which showed that the greater the altitude the smaller the potential gradient.

An exception to this rule was seen at Johannesburg, where the potential gradient was very variable and changed signs at different points in the neighbourhood. These variations were traced to the clouds of steam, and especially of dust, proceeding from the mine heaps. Steam has the effect of increasing the positive gradient, while dust lowers it. To the north of Johannesburg there was a normal positive gradient of 52 volts per metre, whilst at the Observatory, just on the edge of the town, the value was 160; in the town itself the values varied from 0 to 120, whilst at the south end, and to leeward of a mine, from which clouds of dust were rising, the potential was negative, and reached a value of 400 volts per metre. The influence of the mine gave a negative gradient of more than 100 volts at a distance of a mile.

The effects due to dust are much more persistent than those due to steam.

"Respiration and Cell Energy," by Horace A. Wager.

The theory that the energy required in all organic life is derived either directly or indirectly from the sun is disproved. Energy cannot be stored away to be drawn upon when required.

Thus coal does not contain a supply of directly available energy. Its energy is only available when oxygen is available, and so it would be just as correct to say that the energy comes from the oxygen as from the coal. Similarly starch does not contain a store of energy, but energy from some other source is required to decompose it before its constituents can be used in the metabolism of the cell. The first energy available, say, in a germinating cell, probably comes from some synthetic process set up by the introduction of water or oxygen into the cell. In fact the energy set free during the union of oxygen with the liberated carbon is probably the main source of all the energy manifest in organic life. This carbon-dioxide passes away from each cell concerned, and this, together with the introduction of oxygen to the cell, constitutes the process known as respiration. Respiration is not a process separate and distinct from the other metabolism of the cell. In following the course of evolution from simple organisms to more complex all the steps leading towards complexity of structure are intimately bound up with the devices by which oxygen is introduced into the living cells and carbon-dioxide removed from them.

The Anniversary Meeting.

April 17, 1912.

The President, S. S. Hough, F.R.S., was in the Chair.

The Reports of the Secretary and of the Treasurer were read and approved.

The Council for the ensuing year was elected as follows:—

President: L. Péringuey, D.Sc. Hon. General Secretary: J. C. Beattie, D.Sc. Hon. Treasurer: L. Crawford, D.Sc. Members: H. Bohle, M.I.E.E.; J. K. E. Halm, Ph.D.; R. T. A. Innes, F.R.A.S.; C. F. Juritz, D.Sc.; R. A. Lehfeldt, D.Sc.; R. Marloth, D.Sc.; H. H. W. Pearson, Sc.D.; A. Theiler, D.Sc.

The retiring President delivered his address entitled, "Some Recent Improvements in Transit Observing."

Ordinary Monthly Meeting.

May 15, 1912.

The President, L. Péringuey, was in the Chair.

Nominations: A. Devries, by H. Brauns and the President; J. Burton, by H. Brauns and the President.

Elections: Dr. de Wet; Mr. A. C. L. Lloyd.

The General Secretary read the names of candidates proposed as Fellows.

Communications:—

"A Revision of the Genus *Alepidea*, Delaroche," by R. Dümmer.

The paper contains full descriptions of the twenty-three known species of the African genus *Alepidea*, of which eleven are described as new. One of the new species—*A. Thodei*—is figured.

"Positive Electrical Change in Isolated Nerve," by Professor Jolly.

The various theories which have been put forward regarding the causation of positive electrical change in isolated nerve are critically discussed, and the results obtained by different instruments and methods of investigation correlated. The positive after-variation is differentiated from positive change produced during a period of stimulation, and is regarded as depending on two factors: (1) a process occurring in the uninjured part of the nerve subsequent to excitation, and (2) increase in demarcation current.

"A Short Note on the Occurrence of a Leucocytozoon Infection. Host: the Ostrich," by James Walker.

In November, 1911, when investigating the cause of the mortality amongst ostrich chicks on a farm in the Middelburg District, Cape Province, the presence of a Leucocytozoon infection was noted in some instances in blood-smears collected from sick chicks.

The infection has been known to exist on a number of farms in the Cape Province, and it was found in 3–4 months' old chicks showing the symptoms of anaemia, stunted growth, and loss of condition. Although in some cases on post-mortem Strongyli infection was also observed, from the microscopical examination of the blood, which showed a gross invasion of cells by the parasites, the anaemic condition was, in the writer's opinion, attributable to the Leucocytozoon infection.

Microscopical appearance of the parasite in stained blood-smears.—Two main types of the parasite, apparently corresponding to female and male gametocyte, have been noted. The female gametocyte occurs most frequently. The shape varies, it is more or less rounded, but irregular forms are frequent.

The diameter of the rounded forms is from 4 to 15 microns; of the irregular forms, the size varies from 11 to 15 microns in length, and from 9 to 13 microns in width.

The protoplasm stains deeper than in the case of the male gametocyte and scattered throughout it are frequently to be seen a number of metachromatic granules, which are more distinct in some of the parasites. A number of clear spaces appear throughout the protoplasm.

Situated in different positions, namely, towards the periphery or centre of the parasite, is an aggregation of small granules, which apparently represents the nucleus, and, lying in the mass of granules or at the edge of these, a large chromatin granule, average size 1 micron, which stands out distinctly, is seen in most cases.

The male gametocyte is likewise more or less rounded in shape, but distorted forms are not so frequent. The diameter of the rounded forms averages 10 microns.

The chromatin granules are more or less scattered, and the metachromatin granules, noted in the female form, are absent.

The nucleus of the host cell is most frequently elongated or irregular in shape, and usually situated at the edge of the host cell, and appears, in many instances, to be hypertrophied.

Age of affected birds.—A number of smears from ostriches of various age were examined, with the result that the infection was not observed in adult ostriches.

Transmission experiment.—So far gave negative results.

The Leucocytozoon not having been described yet, I propose to call it "*Leucocytoozon struthionis*."

"Valency and Chemical Affinity," by Dr. Moir.

Two and a half years ago the author showed that the atomic weights could be fairly exactly calculated by making use of a proton, μ, of atomic weight, about 0·009. The author has now discovered evidence that this proton may really be, as was suspected in 1909, the true cause of valency and of chemical combination. This evidence consists in the fact that practically the same value of μ is given by the three most exact determinations of molecular ratios that he is acquainted with.

"Description of a New Species of Trygon (*Trygon schreineri*) from South Africa," by Professor Gilchrist.

Three species of the Pijl-staart, or Sting Ray (Trygon), have been recorded from South African waters. A description of a fourth, which seems to be a new species, is now given.

Ordinary Monthly Meeting.

June 19, 1912.

The President, L. Péringuey, was in the Chair.

The Minutes of the Meeting held on May 15th were confirmed.

The President announced that the Council had selected W. A. Jolly, J. Medley Wood, B. de St. J. van der Riet, as candidates for Fellowship. The election will take place at the Annual Meeting on September 18th.

Nominations: L. Carpenter, W. H. Taylor.

Elections: A. Devries, J. Burton.

Communications:—

"The Rainfall on Table Mountain for Thirty Years," by Mr. T. Stewart.

The observing of the rainfall on Table Mountain was begun in January, 1881, by the late Mr. John G. Gamble, M.A., hydraulic engineer to the Cape Colony. For the first three years there were only two stations in use, Disa Head and Waai Kopje; but in 1884 the number was increased by another two, Kasteel Poort and St. Michael's. In 1892 seven additional stations were selected, bringing the total number up to eleven.

The positions of the stations were shown on a map of the Mountain, and the heights above sea-level and other data were given in two tables.

An examination of the data showed that the difference between the rainfall observed at Disa Head and Waai Kopje for the periods of 27 and 30 years was inappreciable, and a comparison of the data for the eleven years, 1893 to 1903 inclusive, with that available for 27 years gave the following:—

Number of Years.	Period.	Average Yearly Rainfall in Inches. Waai Kopje.	St. Michael's.	Kasteel Poort.
—	—	(3,100)	(3,050)	(2,483)
27	1885–1911	67·63	75·24	61·74
11	1893–1903	68·03	75·54	61·09

(*Note.*—The figures in parentheses are the heights above sea-level.)

It may therefore be said that in so far as the determining of the average annual rainfall is concerned, the statistics for the 11 years, 1893 to 1903 inclusive, are as suitable as the data obtained over the period of 30 years.

The first year of the 11-year period was, with one exception (1896), the driest year which has been recorded on Table Mountain, and the three following years, 1894, 1895, and 1896, were the three consecutive driest years. The wettest year of which there is any record, viz., 1902, is also included in the 11-year period.

The summit of the Mountain (Maclear's Beacon gauge) is the wettest place, according to the records; the rainfall at this gauge for the driest year (1896) was 73·34 inches, and for the wettest year (1902) 126·18 inches. The heaviest rainfall recorded for any month fell on the summit during August, 1899, and amounted to 36·58 inches.

"On Tidal Phenomena in Wells near Cradock," by Professor A. Young.

Observations begun in 1905 and carried on at intervals until the present year, on a group of wells on a farm at Tarka Bridge, Cradock District, are described in detail.

The wells have not been bored very deep, the deepest being 225 feet, but it is obvious that the bores connect with deeply extending fissures as the waters issue at temperatures of about 80 degrees, accompanied by large quantities of natural inflammable gas (methane), while sulphuretted hydrogen is present in notable quantities in solution in the water.

Measurements of the pressure at which the water issues show a remarkable fluctuation, in many respects analogous to the tidal fluctuations of the sea.

A series of direct measurements, covering several days, established the fact that there was a real fluctuation, both in the amount of water discharged and in the well-pressure. Continuous records were then obtained over longer periods, by means of clock-driven, self-recording apparatus, in order to study the precise nature of the fluctuations.

The longest continuous record obtained extends over a period of fifteen weeks. This graphical record shows that the semi-diurnal fluctuations attain a maximum amplitude at fortnightly intervals at times corresponding to the times of New Moon and Full Moon throughout the fifteen weeks' period.

This record further demonstrates the fact that the mean daily water pressure rises with each fall of barometric pressure, and falls with each rise in barometric pressure as recorded concurrently at the farm by means of a barograph instrument. The time scale on this fifteen-week record is about 11 inches per week.

Records obtained for shorter periods on a time scale of $13\frac{1}{2}$ inches per day were found to be much more suited for detailed critical examination and analysis. In particular, the record for a certain fortnight during which the barometric pressure was very steady (and, consequently, its interfering effect almost negligible), was selected. The times of all the turning-points were carefully determined in terms of S.A. Official time. The heights of all the turning-points of the curve were also determined in inches.

Similarly, the co-ordinates of all the turning-points for that fortnight were determined on the tide gauge records of the S.A. ports of Cape Town, Port Elizabeth, East London, and Durban.

For general comparison all these measured data were plotted in parallel lines on the same time scale, and the general resemblance of the Well curve to the curves of the coastal tide records demonstrated.

The original Tarka Bridge Record for the fortnight was then subjected to a process of harmonic analysis for the purpose of determining the periods of the principal harmonic components of the curve. The particular method used was described by Chrystal as the method of "Residuation" (Trans. Roy. Soc., Edinburgh, vol. xlv., part 2, pages 385–387).

This method involves no assumptions as to the causes operating to produce the curve. One by one the various simple harmonic components are disentangled from the compound curve with their periods unaltered, but with their amplitudes considerably reduced.

In this way components were isolated from the Tarka Bridge curve, having the following wave periods :—

1. 12 hours 25 minutes.
2. 12 hours 0 minutes.
3. 23 hours 75 minutes.
4. An unharmonic residuum which proved to be the vertical inversion of the barograph curve for the fortnight.

Component No. 13 was obviously not a simple harmonic function. It was apparently composed of several harmonics, of approximately diurnal period, but on the scale on which the analysis was being conducted the practical limit of the method had been reached. Accordingly no finer dissection was attempted.

The above results may be compared with the well-known principal harmonic components of Marine Tides.

1. Principal Lunar semi-diurnal Tide: Period 12 hours 25 minutes 14 1-6th seconds.
2. Principal Solar semi-diurnal Tide: Period 12 hours.
3. Three diurnal tides and periods :—
   23 hours 56 minutes.
   24 hours 4 minutes.
   25 hours 40 minutes 9½ seconds.

The foregoing results seem to establish beyond question that the fluctuations in these wells are to be attributed directly or indirectly to astronomical causes, but the precise nature of the connection is not by any means clear.

The wells are situated over 100 miles from the coast, at an altitude of over 2,700 feet above sea-level. High water at Tarka Bridge occurs about 14½ hours after high water at East London, while the lag in the case of low water is nearly 15 hours.

The principal conceivable theories to account for the phenomena would appear to group themselves in three classes :—

(*a*) Theories depending on the direct gravitative influence of the sun and moon on the land or the underground water.

(*b*) Theories depending on the action of the Marine Tides on the coast loading and distorting the land.

(*c*) Theories depending on the action of Marine Tides in periodically reducing the freedom of outflow of underground water through submarine springs.

No attempt is at present made to state or discuss these theories. It is felt that a satisfactory theory can be arrived at only by the co-operative discussion of the subject by astonomers, geologists, and hydraulicians.

Tidal wells are known in many parts of the world, but practically all are within three or four miles of the seashore, and at no considerable altitude.

One case is reported at Lille, in France, 40 miles from the coast, but at no great height above sea-level. The evidence supporting the tidal claim of this well is far from satisfactory.

It is believed that there is no other record of an inland well showing fluctuations of true tidal periodicity.

Ordinary Monthly Meeting.

July 17, 1912.

The President, L. Péringuey, was in the Chair.

The Minutes of the Meeting held on June 19th were confirmed.

Elections: L. Carpenter, W. H. Taylor.

Communications:—

"Addendum to Revised List of the Flora of Natal," by Mr. J. Medley Wood.

"Descriptions of Some New Batrachia and Lacertilia from South Africa," by Mr. J. Hewitt and Hon. P. A. Methuen.

Natalobatrachus bonebergi, gen. and sp. nov. Belongs to the family Ranidae, and related generically to *Phrynobatrachus*, *Staurois*, and *Oreobatrachus*; distinguishable from the two former by possession of T-shaped terminal phalanges and from *Oreobatrachus* in that the tongue is deeply incised behind and in that there is no continuous dermal fold between the chroanae.

Bufo fenoulheti, sp. n. Related to *B. regularis* and *B. vertebralis*; to be distinguished from the former by the absence of granulations on the belly and in the double sub-articular tubercles of the digits; from the latter through the better developed parotoids and the stronger development of asperities on the dorsal surface.

Tetradactylus eastwoodae, sp. n. Related to *T. breyeri*, Rouz, but distinct from that species by the limb characters. The forelimb possesses three very small digits, all provided with a claw; the posterior limb has two digits, all clawed, the inner digit minute.

Zonurus coeruleopunctatus, sp. n. Distinct from other members of this genus by the small scales of the post-parietal region.

"Notes on Namaqualand Bushmen," by Miss L. Currlé.

The account is taken from a gentleman whose early life afforded him ample facilities for obtaining a clear insight into the characteristics of Cape Colony Bushmen. Their wandering life is noted, also their mode of existence, the K'wè by means of which they procure white ants, their dress and adornments. Nothing comes amiss to them, eating hyaena, jackal, reptiles, and worms. Huts they never build, making only a frail shelter of grass and twigs. The poison they use for their arrows consists of snake-poison and also of that of the large spiders reputed to be very venomous, mixed with the milky juice of an Euphorbia growing in the Langebergen. They practise witchcraft to remove illness, this being done in a very simple manner by the old women. They acknowledge no chief or leader, and are not polygamous, but they have no marriage ceremonies. They are extremely revengeful, killing even their own relations if necessary. Instances are given of this propensity. They believe in resurrection, and bury the dead in a sitting position, so as to enable them to get up easily and walk to a certain place where there is plenty of wild honey and locusts. Those who have been quarrelsome and have behaved badly towards their friends during their lifetime would get common flies to eat as a punishment. The Bushmen believe that jackals, wild cats, &c., were formerly human beings transformed by witchcraft as punishment for evil-doing. They believe also that there was an evil person or devil in the early days who always quarrelled with the others, but from the instances given often had the worst in his encounters.

"A Note concerning the Physical Significance of the Mean Diurnal Curve of Temperature," by Dr. J. R. Sutton.

This paper discusses briefly the question whether hourly average temperatures have any great scientific value. The author comes to the conclusion that it is not unlikely that the mean diurnal curve of temperature is, for Kimberley, made up of at least three superimposed curves of the same period, which curves are proper, perhaps, to various outstanding types of weather.

"A Note on the Earthquakes of the South African Table-land," by Dr. J. R. Sutton.

Occasional shocks of earthquake are felt in South Africa. Four have occurred of sufficient intensity to be plainly felt since the Observatory at Kenilworth (Kimberley) was established. The author calls attention to the fluctuations of barometric pressure which were in progress at the time of these shocks.

Ordinary Monthly Meeting.

August 21, 1912.

Dr. J. K. E. Halm was in the Chair.

The Minutes of the Ordinary Meeting of July 17th were confirmed.

The Chairman announced that Sir David Gill, K.C.B., F.R.S., had represented the Society at the 250th anniversary of the foundation of the Royal Society of London.

The Chairman announced that the Council nominated Sir William

Turner Thiselton Dyer for election as an Honorary Fellow of the Society.

Nominations: Miss A. L. Stephens, Miss A. W. Tucker, Mr. H. J. Hembury, Mr. D. E. Malan.

Communications :—

"The Blizzard of June 9–12, 1902," by Mr. A. G. Howard.

In continuation of the paper by Mr. Stewart, B.Sc., read in November, 1904, before the South African Association for the Advancement of Science, the writer of the present paper brings to notice a series of synoptic charts of the weather conditions from the 8th to the 13th of June, 1902, inclusive. These are commented on, the conclusion arrived at being that the condition shown and explained is the only one bringing a blizzard over the East, although other conditions may bring snow.

"A List of South African Lacertilia, Ophidia, and Batrachia in the McGregor Museum, Kimberley, with Field Notes on Various Species," by Mr. J. Hewitt and Mr. J. H. Power.

The paper is offered primarily as a contribution to our knowledge of the fauna of the Kimberley district. The present-day fauna of that neighbourhood is shown to be composite, a new element having been introduced along with timber from Bechuanaland. The faunistic lists are accompanied with field notes, and in the case of some of the Batrachia the authors have been able to give a short account of the larval metamorphosis.

The collections of the Kimberley Museum also comprise a particularly fine series of reptiles collected in Gordonia by Miss M. Wilman, the Curator, as well as much material from various parts of Bechuanaland and Rhodesia; the records thus obtained relate for the most part to districts which have hitherto not been systematically explored, and as such afford reliable and important data for distribution studies.

"On the Salivary and Mouth Glands of the Nudibranchiata," by Dr. Dreyer.

"The Leaf-spots of *Richardia albo-maculata*, Hook," by W. T. Saxton.

The author describes the structure and development of the white streaks characteristic of the leaves of two species of *Richardia*, and discusses their origin.

The white spots are a conspicuous feature of the mature leaf, but are absent in the very young leaf. They differ from the white regions of the ordinary type of variegated leaf in the fact that the palisade parenchyma is quite absent. The increase in size of the spots is evidently due to divisions of mesophyll and epidermal cells in those regions, in the plane of the leaf, and apparently they originate by the increased meristematic activity of a small group of such cells, while the palisade remains relatively passive, and splits apart at these places.

Plastids are very scarce within the area of the leaf-spots.

A comparison is suggested with the leaves of Monstera, another well-known Aroid.

A drawing and microphotographs were shown, illustrating the structure of the leaf-spots in transverse section.

"Some New or Little-known South African Succulents," by Dr. R. MARLOTH. With plate.

Among the plants dealt with in the present paper are a few of special interest.

Crassula teres belong to the small subgenus Pyramidella, of which *C. pyramidalis* is known to most visitors of the Karroo. Like this and the allied *C. columnaris*, it possesses a fringe of hairs on its leaves, which are capable of absorbing dew or rain-water.

Of the new species of Euphorbia one deserves special mention, viz., *E. ferox*. This forms rounded lumps about a foot in diameter, coloured brown like the soil of the Karroo, and provided with a formidable armament of stout spines. The colonial name "voetangel" is very appropriate, for if a barefooted person should happen to step on such a plant he would certainly not run any further.

Another interesting plant mentioned is *Aloe purpurascens*. This species, so far only known from cultivated plants, is considered by several authors to be merely a variety of *Aloe succotrina*, an error which is due to the want of information we possess about these plants. Up to a few years ago the habitat of neither species was known, and it was even thought that *A. succotrina* came from the island of Socotra and supplied the drug of that island. In fact, in one of the most modern handbooks, viz., Strasburger's, the species is still figured as the source of the drug. When a few years ago *A. succotrina* was found on a field of boulders at the foot of the eastern cliffs of Table Mountain, about 1,000 feet above Newlands, the locality of *A. purpurascens* remained still unknown.

However, plants gathered near the mouth of the Klein River have now flowered in my garden, and show very distinct differences in flowers and leaves from *A. succotrina;* hence the uncertainty about the origin and specific difference of these two species is now removed.

ANNUAL MEETING.

September 18, 1912.

The President, L. PÉRINGUEY, was in the Chair.

Business :—

The following were elected Fellows : Professor W. A. JOLLY, Professor B. ST. J. VAN DER RIET, Mr. J. MEDLEY WOOD.

Ordinary Meeting.

September 18, 1912.

The President, L. Péringuey, was in the Chair.

Business :—

The Minutes of the Meeting of August 21st were confirmed.

The President gave a first notice of the election of the Council, President, and Officers, and announced that the Council recommended to the Society as members of Council in the following year: Dr. L. Péringuey, Dr. L. Crawford, Dr. J. C. Beattie, Mr. S. S. Hough, Dr. J. K. E. Halm, Dr. W. A. Caldecott, Dr. C. F. Juritz, Dr. G. S. Corstorphine, Dr. E. T. Mellor, Dr. A. Jasper Anderson, Dr. E. Warren, and Dr. R. Marloth.

The Council further recommended: Dr. L. Péringuey as President, Dr. L. Crawford as Hon. Treasurer, and Dr. J. C. Beattie as Hon. General Secretary.

The President announced that the Council had awarded the following Grants-in-Aid of Research :—

Hamlin, E. J., Cape Town. Ninety pounds (£90). To carry on research on Commutation in Electrical Machinery.

Young, A., Cape Town. Twenty pounds (£20). To continue investigations on fluctuating well in the Karroo.

Methuen, P. A., Pretoria. Fifty pounds (£50). A journey to the Great Karasberg Range for the study of the Taxonomy and Distribution of the Lower Vertebrates and Several Groups of the Invertebrates of Great Namaqualand.

Rattray, G., East London. Fifty pounds (£50). Travelling expenses in connection with the continuation of investigation of the Taxonomy and Distribution of South African Cycads.

Stephens, Miss E. L., Cape Town. Fifteen pounds (£15). (*a*) Determination of South African Fresh-water Algae. (*b*) Periodic changes in Fauna and Flora of certain South African Vleis.

Tucker, Miss A. W., Johannesburg. Fifty pounds (£50). An Ethnological Survey of the Topnaar Tribe of Hottentots.

Dr. C. F. K. Murray was nominated for membership. Proposed by Dr. J. C. Beattie; seconded by the President.

Conversazione.

A Conversazione was held in the Hiddingh Hall, South African College, Cape Town, at 8.30 p.m. on Wednesday evening, September 18th.

The following is a list of the names of the exhibitors and their exhibits:—

The PRESIDENT. (*a*) Bushmen paintings and gravings.
(*b*) Bushmen statues.
(*c*) Restoration of the head and horns of an extinct South African buffalo.

Miss BLEEK. (*a*) Gramophone record of Bushman speech.
(*b*) Photos of Bushmen dancing.

Professor HAHN. Radiographs of South African minerals.

Hon. PAUL A. METHUEN. Chameleons from Madagascar.

Mr. J. HEWITT. Some new South African tadpoles.

Dr. HALM. Transparencies exhibiting nebulae, star clusters, planets.

Mr. H. E. WOOD. Astronomical photographs.

Miss DOIDGE. South African fungi.

Mr. DE BEER. Apical growth.

Mr. PILLANS. Some South African succulents.

Professor GILCHRIST. Pictures of some South African fishes.

Professor THOMSON. Epidiascope demonstration.

Mr. H. A. WAGER. Some South African mosses.

Professor GODDARD. Zoological exhibit.

Mr. LLOYD. Old South African maps.

Major JARDINE. Old South African maps.

Professor BOHLE. Various electrical instruments.

Professor BEATTIE. Maps showing present state of magnetic survey of South Africa.

Dr. MARLOTH. Glimpses from the desert (with slides).

Professor JOLLY. Demonstration on the electro-physiology of the heart, nerves, and muscles.

Mr. LOGEMAN. Apparatus for rapid evacuation of Röntgen tubes.

Professor RUDGE. Potential curves taken at Bloemfontein.

Professor LEHFELDT. Lumeter.

ORDINARY MONTHLY MEETING.

October, 16, 1912.

The President, L. PÉRINGUEY, was in the Chair.

The Minutes of the Annual Meeting and the Ordinary Meeting of September 18th were confirmed.

W. A. JOLLY and B. ST. J. VAN DER RIET were in attendance and were admitted as Fellows. J. MEDLEY WOOD was admitted *in absentia.*

H. Bayon and J. Walker were nominated as members. Sir William Turner Thiselton Dyer was elected an Honorary Fellow. C. F. K. Murray, E. L. Stephens, A. W. Tucker, H. J. Hembury, D. E. Malan were elected members.

The following papers were read:—

"Note on Double Alternants," by Dr. Thos. Muir.

"Xenopus Laevis (the Plathander)," by Dr. T. F. Dreyer.

"A Short Note on the Occurrence of Aspergillosis in the Ostrich in South Africa," by Mr. James Walker.

The author records the occurrence of Aspergillosis in the ostrich, and from the results of experiments and observations believes this to be the cause of a considerable mortality in chicks and to a less extent in adults. In the author's experiments the fungus concerned was *Aspergillis fumigatus*. The seat of lesions is principally the lungs (pneumomycosis). Young chicks have little resistance thereto, the disease being of short duration and fatal.

"A Preliminary Survey of the Meteorology of Kimberley," by Dr. J. R. Sutton.

This paper is intended as a further contribution to a study of the meteorology of the Table-land of South Africa. Earlier instalments of the same series were published from time to time in the *Transactions* of the South African Philosophical Society. An account is here given, in a statistical and tabular form, of the principal meteorological elements of Kenilworth (Kimberley) all of which, with the exception of the rainfall, are expressed in deviations from the normal monthly means derived from observations made during the last fifteen years.

"Some Geodetic Elements," by Mr. C. Moorsom.

"South African Oligochaeta, Part I., on a Phreodrilid from Stellenbosch Mountain," by Dr. E. S. Goddard and Mr. D. E. Malan.

This paper deals with the anatomy of a new genus of Phreodrilid Oligochaeta, and constitutes the first record of the family in Africa. The specimens were obtained during September, 1911, on the top of Stellenbosch Mountain. The new genus—Gondwanaedrilus—is of special interest since its occurrence in Africa completes in detail the circumpolar distribution of the family. Further, its anatomy is very important since it fills in the last gap in the series of peculiar dispositions and relations of the spermathecae, and leads to a clear understanding of peculiar modifications such as the "autospermatheca" of Phreodriloides—an Australian form. The spermathecal ducts lead anteriorly into an "autospermatheca." The significance of the distribution is also discussed, and the differential characters and inter-relationship of the various genera of the family are summarised.

"Contributions to a Knowledge of South African Oligochaeta, Part II.

Description of a New Species of Phreodrilus," by Dr. E. J. GODDARD and Mr. D. E. MALAN.

This paper gives an account of a new species of Phreodrilus taken on Table Mountain in August. It is specially interesting since it is definitely related to *P. beddardi* and *P. subterraneus.* The peculiar anatomical features concern the dorsal position of the spermathecal pores, and a large hollow penis. The latter corresponds to the penis plus the atrical sac of the other two species mentioned. The study of the new form suggests that Phreodrilus is the central type of the family, and explains the wide distribution of the genus Phreodrilus.

"Contributions to Knowledge of South African Hirudinea, Part II., on some Points in the Anatomy of *Marsupiobdella Africana*," by Dr. E. J. GODDARD and Mr. D. E. MALAN.

In this paper an account is given of the anatomy of Marsupiobdella, a new Glossiphonid leech, with a large internal brood pouch. The main points are concerned with the distortion and displacement of the digestive, nervous, and reproductive systems by the great development of the brood pouch. The pouch is proved to correspond to the large paired ovarial sacs of other Glossiphoniidae and the small ovary to the anterior part of the same. The ovary is traversed by the œsophagus. The oviduct ends blindly near the female pore, and the continuation of the same backwards to the pouch is not the oviduct of other forms but the intermediate portion of their ovarial sacs.

"Portuguese Commemorative Pillars erected on the South African Coast," by Dr. L. PÉRINGUEY.

It is during the reign of John the Second, King of Portugal, that the Portuguese navigators sailed for the first time provided with commemorative pillars, or "Padrãos," to be erected at the furthest point reached, or to mark the progress of their journey. Diogo Cam is the first of these navigators who left Portugal with these regulation pillars. Portuguese historians attribute to him the erection of three, the most southern of which, erected at Cape Cross in 15° 40′ S. in 1486, was rediscovered in 1893. But the old chroniclers are not clear about the number of Padrãos erected by Bartholomew Dias, and hitherto three only were mentioned, whereas it would appear that he put up five: the first, or Padrão Santiago, was erected at Angra Pequena in November, 1487, ten days later the navigator reaches Angra das Voltas, and erects another, but nameless pillar; it is not certain whether this was done on his first landing, or on his return to the place in 1488; in February, 1488, he reaches Algoa Bay and sets a third pillar, Padrão da Cruz, on a small island of that bay; after that he reaches the River Rio Infante, but is compelled to return by his crew; he retraces his way to Algoa Bay, and erects a fourth pillar, Padrão San Gregorio, on Cape Padron, to the east of the bay, in February, 1488; he discovers the Cape of Good Hope (Cabo tormentoso), and erects there a fifth pillar, Padrão San Felipe, probably at Cape Point.

Of all these pillars two only are now known to be in existence, Cam's pillar at Cape Cross, and a fragment of the Padrão Santiago, from Angra Pequena, is in the Cape Museum. The object of this note is to call attention to the possibility of finding some remnants of the others. It is reported that at the mouth of the Orange River, where Dias abandoned his storeship with nine men, and on his return found one survivor only who expired at the sight of his countrymen, rock-gravings reproducing crucifixion scenes have been seen.

Reports of the Hon. General Secretary and the Hon. Treasurer for the Year Ending December 31, 1912.

Seven Ordinary Meetings, the Annual and the Anniversary Meetings, were held during the year, and the following papers were read:—

"On some Meteorological Conditions controlling Nocturnal Radiation," by J. R. Sutton.

"The Resultant of a Set of Homogeneous Lineo-linear Equations," by T. Muir.

"On the Variation in the Value of the Atmospheric Electrical Potential with the Altitude," by W. A. D. Rudge.

"Respiration and Cell Energy," by H. A. Wager.

"A Revision of the Genus *Alepidea*, Delaroche," by R. Dümmer.

"Positive Electrical Change in Isolated Nerve," by W. A. Jolly.

"On the Occurrence of a Leucocytozoon Infection," by J. Walker.

"Valency and Chemical Affinity," by J. Moir.

"Description of a New Species of Trygon," by J. D. F. Gilchrist.

"The Rainfall on Table Mountain for 30 Years," by T. Stewart.

"On Tidal Phenomena in Wells near Cradock," by A. Young.

"Addendum to Revised List of the Flora of Natal," by J. Medley Wood.

"Description of some New Batrachia and Lacertilia from South Africa," by J. H. Hewitt and P. A. Methuen.

"The Physical Significance of the Mean Diurnal Curve of Temperature," by J. R. Sutton.

"Earthquakes of the South African Table-land," by J. R. Sutton.

"The Blizzard of June 9–12, 1902," by A. G. Howard.

"A List of South African Lacertilia, Ophidia, and Batrachia in the McGregor Museum, Kimberley," by J. Hewitt and J. H. Power.

"On the Salivary and Mouth Glands of the Nudibranchiata," by T. F. Dreyer.

"The Leaf-spots of *Richardia Albo-Maculata*, Hook," by W. T. SAXTON.

"Some New or Little-known South African Succulents," by R. MARLOTH.

"Note on Double Alternants," by T. MUIR.

"Xenopus Laevis, The Plathander," by T. F. DREYER.

"The Occurrence of Aspergillosis in the Ostrich in South Africa," by J. WALKER.

"A Preliminary Survey of the Meteorology of Kimberley," by J. R. SUTTON.

"Some Geodetic Elements," by C. MOORSOM.

"South African Oligochaeta, Part I," by E. J. GODDARD and D. E. MALAN.

"Contributions to Knowledge of South African Oligochaeta, Part II.," by E. J. GODDARD and D. E. MALAN.

"Contributions to Knowledge of South African Hirudinea, Part II," by E. J. GODDARD and D. E. MALAN.

"Portuguese Commemorative Pillars erected on the South African Coast," by L. PÉRINGUEY.

"Bushman Sticks decorated on Intaglio and Poker-work," by L. PÉRINGUEY.

"Notes on Namaqualand Bushmen," by Miss L. CURRLÉ.

The PRESIDENT delivered an address: "On some Recent Improvements in Transit Observing."

The Society has awarded, on the recommendation of the General Committee, for Grants-in-Aid of Research, the following grants:—£90 to Mr. E. J. HAMLIN to carry on Experiments on Commutation in Electrical Machinery; £20 to Professor A. YOUNG for the continuation of his investigations on a fluctuating well in the Karroo. A sum not exceeding £100 to Dr. ROBERTS for the construction of a photometer for the photographic survey of the Southern skies. £50 to Dr. G. RATTRAY for the continuation of investigations of Taxonomy and Distribution of South African Cycads. £15 to Miss E. L. STEPHENS for the study (*a*) of South African Fresh-water Algae, and (*b*) of periodic changes in the Fauna and the Flora of certain South African Vleis. £50 to Miss A. W. TUCKER for an Ethnological Survey of the Topnaar Tribe of Hottentots.

The Society held a Conversazione after the Annual Meeting on the 18th of September.

Parts 3, 4, and 5 of Volume II. of the Society's Transactions have been issued during the year.

The number of Honorary Fellows is 5; of Fellows, 48; of Members, 173.

The Society regrets to have to record the demise during the year of P. RYAN, member.

TREASURER'S ACCOUNT FOR THE YEAR ENDING DECEMBER 31, 1912.

Receipts.

	£ s. d.	£ s. d.
To Balance in Bank as per Pass Book		73 6 7
,, Subscriptions received in 1912:		
for 1910, 1 Fellow at £2, 2 Town Members at £2, 4 Country Members at £1	10 0 0	
for 1911, 3 Fellows at £2, balance of 1 Fellow's subscription, 10 Town Members at £2, balance of 1 Town Member's subscription, £1 16s., 16 Country Members at £1	44 16 0	
for 1912, 42 Fellows at £2, 43 Town Members at £2, 92 Country Members at £1..	262 0 0	
for 1913, 14 Country Members at £1, part of 1 Country Member's subscription, 13s..	14 13 0	
for 1914, 1 Country Member at £1 ..	1 0 0	
		332 9 0
,, Entrance Fees received, 13 new members..		13 0 0
,, Commissions received with members' cheques, &c.		1 10 6
,, Government Grant		500 0 0
,, Sale of Publications to Government		100 0 0
,, Sales of Publications otherwise		28 11 3
,, Government Grant (1912) to Professor Pearson for Botanical Exploration in Namaqualand		250 0 0
,, Research Grants: Refund by W. T. Saxton of part of 1911 grant	12 3 7	
,, Refund by P. Methuen of cost of telegraphing 1912 grant..	0 5 0	
		12 8 7
,, Cash drawn from Post Office Savings Bank		400 0 0
,, Sale of Shelving in former Library to S.A. College		10 10 0
,, Subscriptions towards cost of Conversazione		36 6 6
		£1,758 2 5

Expenditure.

		£ s. d.
By Publications		254 3 9
,, Freight, Insurance, Landing Charges, &c.		7 14 1
,, Research Grants and Expenses:—		
Advertising	£3 2 6	
Telegraphing grant to Hon. P. Methuen..	0 5 0	
A. Young, balance 1911 grant	25 0 0	
W. A. D. Rudge, 1911 grant	40 0 0	
Miss A. W. Tucker, 1912 grant	50 0 0	
Miss E. L. Stephens, 1912 grant	15 0 0	
Hon. P. Methuen, 1912 grant	50 0 0	
		183 7 6
,, Money put on Fixed Deposit, Standard Bank, £800, plus cost of stamps on transaction, 4s...		800 4 0
,, Entrance Fees, received 1911, put into Post Office Savings Bank		18 0 0
,, Entrance Fees, received 1912, put into Post Office Savings Bank		13 0 0
,, Payments in connection with 1911 grant to Professor Pearson for Botanical Exploration in Namaqualand		22 6 3
,, Payments in connection with 1912 grant to Professor Pearson for same		140 7 7
,, Compilation for International Scientific Catalogue of papers..		25 0 0
,, Clerical assistance in year and work in Library		22 11 0
,, Local Printing		45 11 6
,, Postages and Petties		43 18 1
,, Bank Charges for Commissions, Ledger Fee, Cheque Book, &c.		3 2 9
,, Hire of rooms for meetings and caretaker		5 15 6
,, Address to Royal Society of London, on its 250th Anniversary		1 10 0
,, Four copies S.A. Phil. Soc. Transactions, Vol. 5, Pt. I.		2 11 0
,, Minute Books..		0 18 9
,, Expenses of Conversazione..		29 2 6
,, Balance in Bank as per Pass Book		138 18 2
		£1,758 2 5

ASSETS AND LIABILITIES AS AT DECEMBER 31, 1912.

Assets.

	£	s.	d.
Money at Standard Bank on Fixed Deposit at 4 per cent.	800	0	0
Money in Post Office Savings Bank, Life Subscriptions and Entrance Fees	95	0	0
Money in Post Office Savings Bank, including Interest to March 31, 1912..	219	14	1
Balance in Standard Bank as per Pass Book	138	18	2
Petty Cash in hands of Hon. Secretary	4	8	2
Petty Cash in hands of Mr. H. E. Wood, Johannesburg..	3	7	6
Arrears of Subscriptions, as in Statement for 1911, due at beginning of 1912, £84 16s., less £51 16s. paid in 1912, and £20 struck off as irrecoverable	13	0	0
Arrears of 1912 subscriptions	49	0	0
Money paid in advance for Publications	46	0	0
	£1,369	7	11

Liabilities.

				£	s.	d.
Subscriptions received for 1913 and 1914				15	13	0
Balance of grant for Botanical Exploration in Namaqualand (Professor Pearson)				109	12	5
Balance of Research Grants voted 1911 :						
Miss D. F. Bleek, £35				35	0	0
Balance of Research Grants voted 1912 :						
E. J, Hamlin	£90	0	0			
G. Rattray	50	0	0			
A. W. Roberts	100	0	0			
A. Young	20	0	0			
				260	0	0
Balance from 1912 Conversazione carried forward toward the expenses of future Conversazione in Cape Town..				7	4	0
				£427	9	5

LAWRENCE CRAWFORD, Hon. Treasurer.

I have audited the accounts and checked the vouchers of the Royal Society of South Africa for the year 1912, and find the same, to the best of my belief, to be correct.

A. D. R. TUGWELL,
February 6, 1913.

LIST OF OFFICERS, FELLOWS AND MEMBERS.

December 31, 1912.

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de Villiers, Baron. J. H. de Villiers, *P.C., K.C.M.G., LL.D.*, Wynberg, C. P.

du Toit, A. L., *D.Sc.*, Geological Survey, Cape Town.

Gilchrist, J. D. F., *M.A., D.Sc., F.L.S., Ph.D.*, South African College, Cape Town.

Goetz, *Rev.* E., *S.J.*, The Observatory, Bulawayo, Southern Rhodesia.

Hahn, P. D., *M.A., Ph.D.*, South African College, Cape Town.

Hall, A. L., *B.A.*, Geological Survey, Pretoria.

Halm, J. K. E., *Ph.D.*, Royal Observatory, Cape.

Hough, S. S., *M.A.*, *F.R.S.*, Royal Observatory, Cape.

Innes, R. T. A., *F.R.A.S.*, Union Observatory, Johannesburg.

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Lounsbury, C. P., *B.Sc.*, Department of Agriculture, Pretoria.

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Young, R. B., *M.A.*, *B.Sc.*, School of Mines and Technology, Johannesburg.

Zealley, A. E. V., *A.R.C.S.*, Geological Survey, Bulawayo, S. Rhodesia.

ADDITIONS TO THE LIBRARY DURING 1912.

Aarau, Switzerland.

Verhandlungen der Schweizerischen Naturforschenden Gesellschaft. 94 Jahresversammlung vom 31 Juli bis 2 Aug., 1911, in Soluthorn, Band i., Band ii.

Adelaide.

Adelaide Observatory.

Meteorological Observations made at the Adelaide Observatory and other places in South Australia and the Northern Territory. Years 1906, 1907.

The Royal Society of South Australia.

Transactions and Proceedings and Report, vol. xxxv., 1911.

Amsterdam.

Koninklijke Akademie van Wetenschappen te Amsterdam.

Royal Academy of Sciences.

Proceedings of the Section of Sciences, vol. xiv., parts 1, 2.

Verslag van de Gewone Vergaderingen der Wis-en Natuurkundige Afdeeling, Deel, xx., Gedeelte 1, 2.

Austin, Texas, U.S.A.

The University of Texas.

Bulletin, Nos. 135, 136, 137.

The Texas Academy of Science.

Transactions, 1907. Together with the Proceedings for the same year, vol. x.

Baltimore, U.S.A.

The Johns Hopkins University.

The Johns Hopkins University Circulars, 1911, Nos. 3, 4, 5, 6, 7, 8, 9, 10; 1912, No. 1.

Johns Hopkins University Studies in Historical and Political Science, series xxvi., Nos. 7–8; series xxix., Nos. 1, 2, 3; series xxx., No. 1.

Bulletin of the Johns Hopkins Hospital, vol. xxii., No. 250; vol. xxiii., Nos. 251, 252, 253, 254, 255, 256 257, 258, 259, 260, 261.

BASEL.

Naturforschenden Gesellschaft in Basel.

Verhandlungen, Band xxii.

BERKELEY, CAL., U.S.A.

University of California Publications.

Botany, vol. iv., Nos. 12, 13, 14, 15.

Geology, vol. vi., Nos. 15, 19; vol. vii., Nos. 1, 2, 3, 4, 5.

Physiology, vol. iv., Nos. 8, 9 and 10, 11, 12 and 13, 14 and 15, 16, 17; vol. vi., No. 6.

Zoology, vol. vii., No. 10; vol. ix., Nos. 1, 2, 3, 4, 5, 6, 7, 8; vol. x., Nos. 1, 2, 3 and 4, 6 and 7, 8; vol. xi., No. 1.

Memoirs, vol. i., No. 2, part 1, part 2.

College of Agriculture—Agricultural Experiment Station. Bulletin, Nos. 218, 219, 220, 222, 223, 224, 225, 226, 227, 228.

BERLIN.

Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften, 1911, xxxix.–xl., xli., xlii.–xliii., xliv., xlv.–xlvii., xlviii.–xlix., l., li.–liii.; 1912, i.–iii., iv., v.–vi., vii., viii.–ix., x.–xii., xiii., xiv.–xv., xvi.–xviii., xix.–xxi., xxii.–xxiv., xxv., xxvi.–xxvii., xxviii., xxix.–xxx., xxxi., xxxii.–xxxiv., xxxv., xxxvi.–xxxvii., xxxviii.

BOLOGNA.

R. Accademia delle Scienze Dell' istituto di Bologna.

Rendiconto, Serie Prima, vol. iv. (1910–11); Serie Prima, vol. v. (1911–12).

Memorie, Serie i., Tomo v., 1910–11, Sezione di Scienze Storico-Filologiche, Fascicolo Unico. Sezione di Scienze Giuridiche. Fascicolo Unico. Serie i., Tomo vi., 1911–12, Sez. di Sci. Stor. Fil. Fasc. Unico; Serie i., Tomo vi., 1911–12, Sez. di Sci. Giur. Fasc. Unico.

BOULDER, COLO., U.S.A.

The University of Colorado Studies, vol. ix., Nos. 1, 2, 3. 4.

BROOKLYN, U.S.A.

The Museum of the Brooklyn Institute of Arts and Sciences.

Science Bulletin, vol i., No. 17; Index to vol. i.

BRUXELLES.

Academie Royale de Belgique, Bulletin de la Classe des Sciences, 1911, Nos. 9, 10, 11, 12; 1912, Nos. 1, 2, 3, 4, 5.

Annuaire, 1912.

Buenos Aires.

Museo Nacional de Historia Natural de Buenos Aires.

Annales, Tomo xxii., Serie iii., Tomo xv.

La Sociedad Physis Para el Cultivo y Difusion de las Ciencias Naturales en la Argentina.

Boletin, Tomo i., Nos. 1, 2.

Bulawayo.

Rhodesia Museum.

Tenth Annual Report, 1911.

Calcutta.

The Asiatic Society of Bengal.

Memoirs, vol. ii., Index; vol. iii., No. 2, pp. 57–94, No. 3, pp. 95–248, No. 4, pp. 249–277; vol. iv., No. 1, pp. 1–127.

Journal and Proceedings, vol. v., Index, Dates, Directions, List of Papers, vol. vi., Nos. 7, 8, 9, 10, 11; vol. vii., Nos. 1, 2, 3.

Cambridge, England.

Cambridge Philosoph. Society.

Proceedings, vol. xvi., parts 3, 4, 5, 6, 7, 8.

List of Fellows, etc., 1912.

Cambridge University Library, Report of the Library Syndicate. Year ending December 31, 1911.

Cape Town.

The South African Public Library.

Catalogue of the Serial Publications possessed by the Geological Commission of Cape Colony, the Royal Observatory, the Royal Society of South Africa, the South African Association for the Advancement of Science, the South African Museum, and the South African Public Library. With an Appendix containing a list of the Serials in the Bolus Herbarium of the South African College.

Cape Town.

Annals of the South African Museum, vol. x., parts 2, 3; vol. ix., part 2; vol vii., part 5.

Geological Commission.

Geological Map of the Province of the Cape of Good Hope. Sheet 19 (Nieuwerust); Sheet 26 (Dordrecht, Barkly East).

South African Association for the Advancement of Science.

The South African Journal of Science, vol. viii., Nos. 5, 6, 7, 8, 9, 10, , 12; vol. ix., Nos. 1, 2, 3, 4, 5.

CASSEL.

Verein für Naturkunde zu Cassel.

Festschrift, 1911.

CHICAGO, U.S.A.

Field Museum of Natural History.

Report Series, vol. iv., Nos. 1, 2.

Geological Series, vol. iii., No. 9.

Zoological Series, vol. x., Nos. 5, 6 ; vol. xi.

CINCINNATI, OHIO, U.S.A.

The Lloyd Library of Botany, Pharmacy, and Materia Medica.

Bulletin, No. 17. Pharmacy Series, No. 3.

,, ,, 18. ,, ,, 4.

,, ,, 19. ,, ,, 5.

,, ,, 16. Botany Series, No. 2.

,, ,, 20. Mycological Series, No. 6.

Bibliographical Contributions, No. 4, October, 1911; No. 5, January, 1912; No. 6, April, 1912.

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