

CONTRIBUTIONS TO A KNOWLEDGE OF THE
ANATOMY AND DEVELOPMENT OF THE
MARSUPIALIA.

NO. I. THE GENITALIA OF *SARCOPHILUS SATANICUS* (♀).

BY T. THOMSON FLYNN, B.Sc., LECTURER IN BIOLOGY,
UNIVERSITY OF TASMANIA.

(Plates xxvi.-xxxi.)

Introductory.—The specimen of *Sarcophilus satanicus*, of whose genital organs this communication is a description, was forwarded to me through the kind offices of Mr. J. E. C. Lord, of Hobart, in August, of last year. I wish also to express my indebtedness to several other gentlemen, notably Mr. W. Stops, and Dr. J. S. C. Elkington, for their endeavours to obtain specimens for this work. This is the only female which I have as yet obtained, and I had originally intended that its description should wait until further specimens had come to hand; the increased scarcity, however, of these animals, together with the discovery of a number of interesting and significant points in the morphology of the genital organs, has influenced me to publish the results earlier than otherwise would have been the case. Portions of the paper can as yet be regarded only as preliminary notes. This is due, in the first place, to scarcity of material, and, in the second, to an unfortunate lack of original communications and papers in Tasmania. I have had to depend on my friends, especially Professor Haswell and Acting-Professor Johnston, of Sydney, to remedy somewhat my deficiencies in this respect, and I here take the opportunity of thanking them sincerely for the help they have given me.

Description of specimen.—The specimen was a full-grown female, with three fairly advanced young in the pouch. All had

been dead for two days. The pouch-young were fixed entire in corrosive- sublimate- acetic-solution, the genital organs of the mother in picro-sulphuric solution. In this latter case, on sectioning, it was found that what blood there was in the vessels had hardened so much, that it was only with extreme care and difficulty that sections could be cut at all. The hopeless gapping of the razor-edge, with consequent damage to the sections, is well indicated in Fig.10.

The present paper consists of two parts. One is a description of the genital organs of a pouch young measuring 65 mm. in greatest length, not meant to be exhaustive, but merely for comparison with the adult organs; the other contains an account of the adult genital organs.

i. ON THE GENITAL ORGANS OF A 65 MM. POUCH-YOUNG OF
SARCOPHILUS SATANICUS.

External features of embryo.—Measurements: H.L. 33·5 mm.; snout to root of tail (along dorsal curvature) 90 mm.; tail 20·5 mm.; arm 25 mm.; leg 21 mm.; foot 10 mm.

Body seemingly naked, but really covered with minute, very fine hairs; of the general body-hairs those on top of the head, snout, and back are rather longer than others. There are well developed vibrissæ (8 mm. in length); there are about eight strong hairs above the eyes, and twenty in a patch below and behind them. On the shut and united eyelids, eyelashes are fairly well developed. A small bundle of eight or nine specialised hairs is placed on a small elevation on the postero-internal side of the arm. The leg is devoid of special hairs. The lips are quite united, as well as the eyelids. The ear-pinna is quite free, and directed backwards. The umbilical scar is almost obliterated. The marsupium consists of two contiguous deep sacs, with teat-rudiments. Clitoris visible, and external. Limbs well developed; fore-limb with five clawed digits, first shortest, third and fourth longest, second and fifth equal and intermediate; hind-limb with four equal toes.

The embryo seemingly corresponds, in age, with the late mammary foetus of *Trichosurus vulpecula*, figured by Broom(2, Fig.14), of which he says it "differs but little in its character from the adult."

Genital Organs.—These are shown in Fig.2. In external appearance their arrangement is similar to that of similar organs in the adult(Fig.1). The ovaries are small, compressed, oval bodies, quite smooth, with a length of 2 mm., and a breadth of 1.5 mm. Stretching back from the ovaries are visible the two genital cords, containing the Müllerian ducts and vestiges of the Wolffian ducts, here confined to a short, blind passage from the genital cord, through the mesoarium, and ending blindly in the substance of the ovary. The genital cords pass back to meet dorsally to the bladder. Between the Müllerian ducts pass the ureters, to enter the bladder; and shortly after this, there is formed, for a short distance, what Hill(3) has called, in the adult *Perameles*, the urogenital strand, containing as it does the vaginal portions of the Müllerian ducts and the urethra. A little behind this, however, the two Müllerian ducts open into the urogenital sinus, which is directly continuous with the urethra. Most of the cylindrical mass of tissue, then, seen in Fig.2, posterior to the bladder, is not urogenital strand, but the enclosing tissue of an extremely long and narrow urogenital sinus. It measures 6 mm. long, by an external width of from 1-2 mm.

Microscopic Structure.—The Ovaries: sections show that the differentiation into primitive ova and follicular cells is just in progress. The Müllerian ducts are contained in the genital cords. Each duct is a fairly convoluted tube opening, in front, into the abdomen by the ostium abdominale tubæ, and behind into the urogenital sinus. The anterior portion of the duct has an average breadth, in section, of 0.072 mm. The uterine portion of the duct is much enlarged to form the *anlage* of the uterus. This enlargement is not visible externally. When the two genital cords come together dorsally to the bladder, where the two cords almost completely fuse, the two Müllerian ducts remain quite distinct, separated by a wall of connective

tissue averaging 0.19 mm. in thickness. Farther back (Fig. 4), the Müllerian ducts (*l.vag.c.*) are now seen to diverge gradually, but between, is a mass of connective tissue (*x*) which soon remains stranded between them, as shown in Fig. 5, where the Müllerian ducts (*l.vag.c.*) are now seen to be still more separated. This deeply staining mass of connective tissue (*x*) gradually disappears in sections, lasting, all told, through 80. It is the indication, in the embryo, of the future median vaginal cul-de-sacs (and possibly of a portion of the pseudovaginal passage), passing, as it does, backwards from the point where the Müllerian ducts begin to diverge posteriorly.

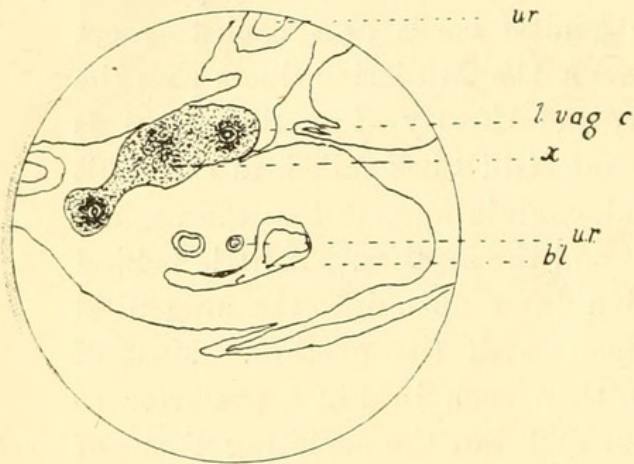


Fig. 4.

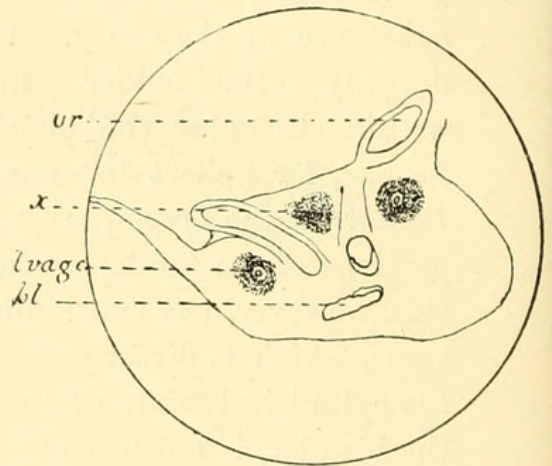


Fig. 5.

The two Müllerian ducts now approach one another, and come to lie parallel in the narrow cylinder of tissue continuous with the connective tissue enclosing the urogenital sinus, and known as the urogenital strand. Each measures on an average 0.057 mm. in diameter. Twenty-eight sections after the disappearance of the connective tissue (*x*), they open into the urogenital sinus, as shown in Fig. 6.

The urogenital sinus has a very definite lumen, with a number of longitudinal grooves; two of these are dorsal or dorso-lateral, one is ventral, the others are ventral or ventro-lateral. The two lateral vaginal canals open into the right and left dorsal grooves. Owing to an accident, the whole of the clitoris could not be

sectioned. The portions seen, however, showed the median septum, and the two lateral septa, with a semicircular mass of erectile tissue arranged round the latter, much as is found in the adult *Phascolarctos*.

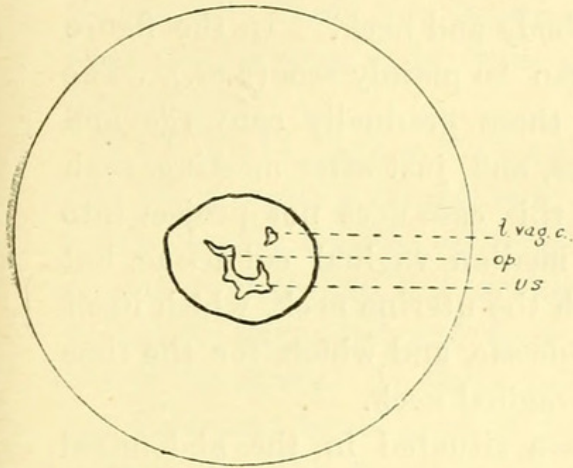


Fig. 6.

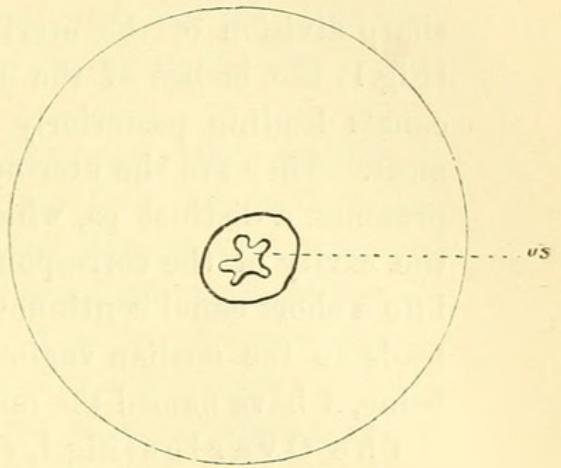


Fig. 7.

ii. ON THE ANATOMY OF THE GENITAL ORGANS OF AN ADULT FEMALE *SARCOPHILUS SATANICUS*, WITH THREE ADVANCED POUCH-YOUNG.

External appearance of the Genital Organs.—The genital organs are shown in Fig.1. They comprise two ovaries, two Fallopian tubes, two uteri, the median vaginal apparatus, two vaginae, and a long urogenital sinus. A general glance at Fig.1, and a comparison of the figure with Hill's drawing of the genital organs of *Perameles*(3, Fig.1) would give rise to the impression that in *Sarcophilus*, as in *Perameles*, there is present an elongated strand of tissue, the so-called urogenital strand. But this is not so. Sections show that the long cylindrical mass of tissue(*u.s.*) seen in Fig.1, is almost entirely the wall of an elongated urogenital sinus, only the most proximal portion of this tissue representing the urogenital strand. But there is an important point of agreement between the genital organs of *Perameles* and *Sarcophilus*, which needs to be fully emphasised; in both we have, in the adult, a condition of the genital organs characterised by Hill(3) as "persistently embryonic," inasmuch as the posterior

portions of the Müllerian ducts, together with the median vaginal apparatus, remain permanently embedded in the tissue extending between the median vaginal canals and the urogenital sinus, —the persistent genital cord.

Another point, to which I wish to draw attention here, is the sharp division of the uteri into body and neck. In the figure (Fig.1) the bodies of the uteri can be plainly seen(*r.ut.*). The canals leading posteriorly from these gradually converge and meet. They are the uterine necks, and, just after meeting, each presents a distinct os, which in this case does not project into the cavity of the corresponding median vaginal cul-de-sac, but into a short canal continuous with the uterine neck, which itself leads to the median vaginal cul-de-sac, and which, for the time being, I have named the median vaginal neck.

The Ovaries (Fig.1, *r.ov.*) are situated in the abdominal cavity, some distance in advance of the pubic symphysis. They are somewhat compressed oval bodies, with the long axis oblique to the long axis of the animal. In this specimen, they measure in length 7.5 mm., in breadth 5 mm. The surface is almost smooth and finely granulated. The direction of the long axis of the ovary to the long axis of the animal is by no means constant on different sides of the same animal, as Fig.1 indicates. In *Perameles* the ovaries are situated dorsally to the uteri. In *Sarcophilus* they are placed well in front (distant about 10 mm.) of the uteri. The ovaries are widely separated from one another, and are fully visible in the natural condition of the parts. Between them stretches the median, united portion of the broad ligament. To this, the ovaries are attached by thickened, upward invaginated portions.

Of the ovaries of *Perameles*, Hill says, “. . . they lie enclosed, together with the fimbriated openings of the Fallopian tubes, in peritoneal pouches formed by the broad ligaments. The pouches lie dorsal to the uteri, and open posteriorly by wide apertures into the dorsal uterine fossa.”(3)

In *Sarcophilus*, on the other hand, the ovaries are not contained in any pouches, but are freely and fully visible from above.

However, immediately behind the ovaries there is a downwardly directed pouch-like invagination of the broad ligaments, 4 mm. in depth. The mouth of each invagination is directed upward and mesially. In the outer wall of this invagination run the ovarian ligament, and also the round ligament for a portion of its course. These two ligaments arise from the uterus in such close combination as to form a single ligament, the two shortly separating.

The Fallopian Tubes (Fig. 1, *f.t.*) are rather peculiar in not being greatly convoluted. They are thin, but well defined tubes sharply marked off from the uteri behind, and extending almost in a straight line, without any great convolution, forward to become expanded and fimbriated. The fimbriæ only slightly invest the ovary. In their course between the ovaries and uteri, the Fallopian tubes have to pass through the above-mentioned pouches, dipping down in the anterior wall traversing the floor, and rising again before each expands to form the uterus.

Uteri.—These (Fig. 1, *r.ut.*) have a peculiar shape, which, however, is quite comparable with the shape of the similar organs in *Perameles*. Each is many times longer than wide, and is divided into two portions, a “body” and a “neck.” The two portions are quite sharply and distinctly marked off from one another. While in *Perameles* “the two bodies of the uteri lie with their mesial surfaces in apposition, except anteriorly where they are separated over a short part of their extent and connected by the common median portion of the ligamenta lata”(3), in *Sarcophilus* they are completely separated from one another by a considerable space occupied by the common forward and median expansions of the broad ligaments. Each body has, in external view, the inner side flatter in shape than the outer; and in section the uterus is subtriangular, with the flat inner side perpendicular, and the dorsal and ventral surfaces meeting at a somewhat blunt angle on the outer side of the uterine body. The dimensions of the uterine body are, length 14 mm., greatest breadth 6 mm.

Microscopic Structure of the Uterus.—This is similar to that described by Hill, for *Perameles*(5). The serous

layer is practically uniform in thickness (0.08 mm.) except at the two points where the broad ligaments become continuous with it, where it is much thickened. Within the serous layer is the muscular layer composed entirely of plain, circularly running fibres. Blood-vessels pass from this layer into the mucous layer, and penetrate to a point just below the inner epithelium. The mucous layer is characteristically disposed. On the two sides where the broad ligament becomes continuous with the serous layer, the mucosa is much thickened, forming two large cushion-like projections into the lumen of the uterus, measuring in thickness 1.1 mm.; on the dorsal and ventral sides of the uterus, however, the mucosa becomes much reduced in thickness, measuring only 0.19 mm. The uterine glands, even at this stage, are somewhat smaller than in the virgin *Perameles*, having a very small lumen, measuring from 0.016 mm. to 0.035 mm. in diameter. The mucous membrane is covered by a columnar epithelium measuring, in thickness, about 0.027 mm.

Uterine Necks.—These (Fig. 1, *ut.n.*) resemble externally the Fallopian tubes. Each is quite distinct from the uterine body. Internally the surface of each uterine neck is raised into folds and ridges. Each neck ends in a distinct os, some distance anterior to the point where all the ducts become blended into one mass. The two necks approximate, and run side by side, separated by a wall of connective tissue 0.506 mm. in thickness, which, further back, decreases, by further approximation of the necks, to 0.476 mm. Each os is extremely well defined, and of large extent, differing markedly in this respect from the similar structure in *Perameles*. The os of the left uterus extends through eighty sections of medium thickness.

Median Vaginal Apparatus.—This consists, on each side, of a median vaginal cul-de-sac, which is quite distinct from its fellow of the opposite side, and separated from it by a thick, complete partition-wall. The right median vagina is considerably larger than the left. The whole arrangement of the median vaginal apparatus is irregular. Each of the median vaginal cul-de-sacs is a large, irregular chamber of no defined shape. The

method of entry and exit of the ducts leading to and out of each median cul-de-sac, varies on each side, and seems to be arranged on no settled plan. Leading from the uterine necks, posteriorly to each os, is a fairly wide canal, which is, seemingly, quite distinct, in this specimen, from the median vaginal cul-de-sac. This is to be regarded as an anterior portion of the vaginal section of the Müllerian ducts, which has not entered into the formation of the cul-de-sacs proper. Pending further enquiries into the relationship of this canal in the virgin, I have called it, for the time being, the median vaginal "neck." The vaginal necks on either side have a quite different arrangement. On the left side, eighty-three sections behind the point where the os ends, there appears, a short distance outside the left vaginal necks, a couple of small cleft-like openings which soon coalesce and enlarge, forming an irregular chamber, the left median vaginal cul-de-sac. The shape of the chamber is indefinite, but it is lined by a well marked epithelium, the cells of which contain large rounded nuclei. Further back the arrangement is as seen in Fig.8. The left median vaginal cul-de-sac is now a long, low chamber, from which, on the outer side, is being separated off a portion to form the lateral vaginal canal, this being recognised by the longitudinal foldings and corrugations in its walls. This latter soon becomes separated from the left median cul-de-sac as a distinct duct. Just anterior to the sections shown in Fig.8, there has appeared, on the inner ventral side, a number of irregular spaces which soon coalesce to form the large, irregular chamber shown in Fig.8(*r.m.v.c.*). The position in which these spaces first appear, is at the inner lower angle of the chamber (*r.m.v.c.*) shown in that figure. The point of exit of the right lateral vaginal canal is shown by the foldings appearing at the lower outer angle of this chamber. Soon the right lateral vaginal canal becomes quite separated from the corresponding median cul-de-sac of that side. The irregularity of the whole arrangement can be seen if it be noted that, in the case of the *left* median vaginal cul-de-sac, the so-called median vaginal neck enters it from the *inner* side, while the lateral vaginal canal exits from

it on the *outer* side; on the *right* side, the median vaginal neck enters the cul-de-sac from its *outer* side, and leaves it by the *outer* side.

The peculiar and irregular arrangement indicated here, points to one of two conclusions.

(i.) That, in this Marsupial, the median vaginal cul-de-sacs are not present in the virgin, and that they are mechanically caused by the resting of the embryos in their course outwards; or, which is more probable,

(ii.) That the enlargement of the median vaginal cul-de-sacs, if present in the virgin, is not a result of conception, but a mechanical result of the passage of the embryo itself.

Of these, the first is virtually disproved by the presence of the epithelial lining to the median vaginal cul-de-sacs.

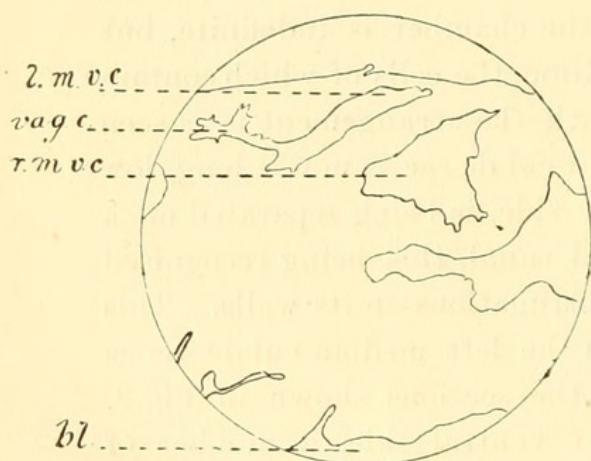


Fig. 8.

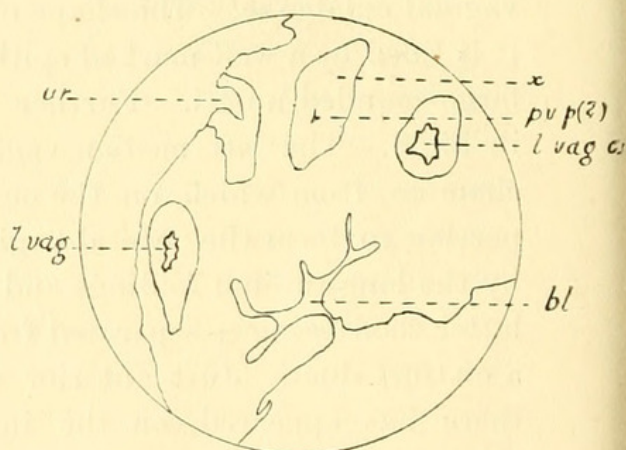


Fig. 9.

We have now in section, therefore, two median vaginal cul-de-sacs lying side by side, but separated by a fairly thick wall, which becomes still thicker further back. Posteriorly the median cul-de-sacs terminate blindly in irregular spaces similar to those in which they began. There is no sign of any inter-communication between the vaginal cul-de-sacs, the intervening partition being quite complete and unperforated. A study of Fig. 9, some sections behind Fig. 8, shows that this form exhibits, in common with *Perameles*, that primitive arrangement in which the posterior

portions of the Müllerian ducts remain permanently embedded in the persistent genital cord of the embryo. In the position where the median vaginal cul-de-sacs disappear, there remains, occupying the central portion of the cord, a mass of deeply staining tissue, in the lateral portions of which the lateral vaginal canals are enclosed. Sectioning further back, the lateral vaginal canals are found to diverge and lose connection with this central mass of tissue. They soon come to lie at the surface, and the central, deeply staining mass has become of rhomboidal shape, as shown in Fig. 9, where are also seen, between this mass and the lateral vaginal canals, the inpassing ureters.

The divergence of the lateral canals is still greater in Fig. 10, somewhat behind Fig. 9, and the central mass has still further changed its shape, as shown in the figure. After the ureters have entered the bladder, the lateral vaginal canals quickly converge, to enter the short cylinder of tissue continuous externally with the wall of the urogenital sinus, and corresponding to the urogenital strand of *Perameles*. The lateral vaginae now come again into relation with the central mass, and, shortly after this, become quite obliterated without any lumen. These

closed canals can be seen to come into relation with the urogenital sinus. The deeply staining mass above spoken of (x) represents the path of the pseudovaginal passage. The presence of this passage is indicated by various breaks or splits in the tissue, some of which extend through a considerable number of sections. At the anterior

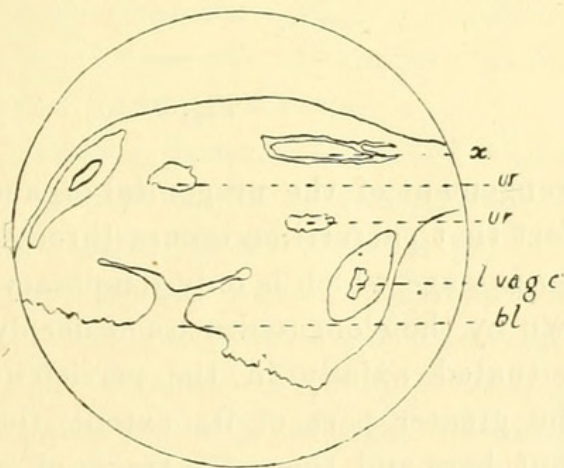
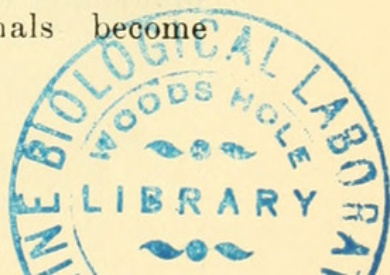


Fig. 10.

and posterior ends, however, the passage has quite healed up. The central mass (x) comes into relation with the lateral vaginal canals at the point where these canals become



obliterated. A section in this region is shown in Fig.11, where the obliteration of the canals can be well seen. In Fig.12, the portion of the urogenital sinus into which the lateral vaginal canals would open in their functioning condition, is shown. Its irregular and torn shape will at once be noted. It should be compared with Fig.6, showing an exactly similar section of the urogenital sinus of the embryo. The urogenital sinus is extremely long, measuring 42 mm. in length. It opens into the cloaca on the ventral side. The clitoris is bifid at the extremity, and attached throughout nearly its whole length.

The cloaca is a large, well marked chamber. A pair of anal glands is present.

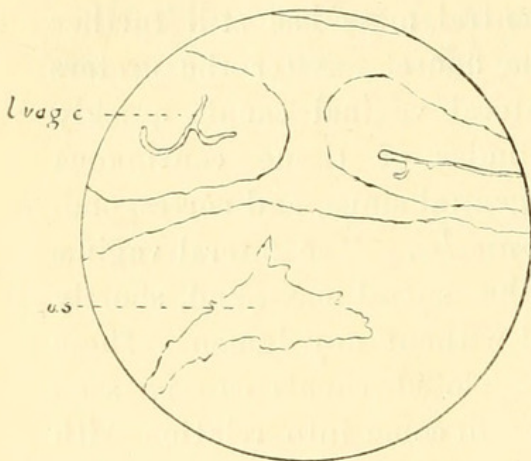


Fig. 11.

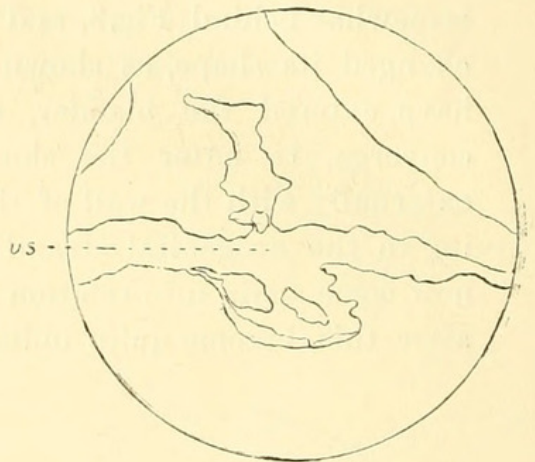


Fig. 12.

Parturition.—The arrangement of the urogenital organs in *Sarcophilus* points to the fact that parturition occurs through the medium of a direct median passage which is only temporary, but the track of which is shown by the elongated mass of deeply staining, connective tissue situated axially in the persistent genital cord. Throughout the greater part of its extent, the passage becomes obliterated, but here and there the traces of it can be seen; and, at the posterior end, the obliterated remains of the lateral vaginal canals come into relation with the urogenital sinus, along a long, dorsally situated, deep fissure which, in my opinion, is undoubtedly caused by the breaking of the embryos.

from the pseudovaginal passage into the sinus. There is evidence of a considerable tearing and breaking of the tissues in this region. Figs. 11 and 12, representing sections through this region in the adult, should be compared with Figs. 6 and 7 of the similar regions in a well advanced pouch-young. In Figs. 6 and 7, the urogenital sinus is of definite contour, and the lateral vaginal canals (Müllerian ducts) are quite open, definite canals plainly to be seen entering the urogenital sinus. In Figs. 11 and 12, the urogenital sinus is seen to be considerably torn and partially filled with corpuscular debris. The dorsal fissure shown in Fig. 12 comes into direct relation, in the section, with the left vaginal canal. There is also noticeable in this region a considerable quantity of extravasated blood. The obliteration of the hinder ends of the lateral vaginal canals, in my opinion, can only be caused by the embryos meeting them in their course backwards and outwards, and actually tearing them away, or so compressing them that they lose their identity. Although in the specimen, the young are fairly well advanced, yet the lateral vaginal canals have not been able to regain their functional condition. Repair, then, must be exceedingly slow, and for a considerable time after parturition the lateral canals must be functionless, as carriers of the spermatozoa. Such a condition of the lateral canals, consequent upon parturition has, so far as I know, never yet been noted for any marsupial.

General Remarks.—Though conclusions drawn from the result of an examination of one specimen are, in many cases, apt to be premature, yet *Sarcophilus* presents, in the morphology of the female genital organs, a number of features of special interest, to which it is necessary that attention be drawn.

The arrangement of its female genital organs is undoubtedly primitive—the presence of the persistent genital cord, the complete separation, even after parturition, of the median cul-de-sacs, the large and definite cloaca all prove this—but whether it is as primitive as such a form as *Perameles*, is not so capable of proof. There is, on the one hand, an absence of any specialised structures, such as the larger vaginal cæca of *Perameles*; but, on the other,

the presence of distinct ora separating the uterine and vaginal segments of the Müllerian ducts, and an elongated urogenital sinus are points in which the genital organs of *Sarcophilus* are relatively more advanced than those of *Perameles*. At present, I will content myself, for the purposes of this paper, with merely briefly pointing out above these points, reserving discussion, at a greater length, for the future, when a larger number of specimens have been examined.

BIBLIOGRAPHY.

1. WIEDERSHEIM and PARKER.—Comp. Anat. of Vertebrates. London, 1907.
2. BROOM, R.—“A Contribution to the Development of the Common Phalanger.” Proc. Linn. Soc. N. S. Wales, 1898, p.705.
3. HILL, J. P.—“Contributions to the Morphology and Development of the Female Urogenital Organs in the *Marsupialia*, No.i.” Proc. Linn. Soc. N. S. Wales, 1899, p.42.
4. ————“Contributions, etc., Nos.ii.-v.” *Op. cit.* 1900, p.519.
5. ————“Contributions to the Embryology of the Marsupialia.” i. Quart. Journ. Micr. Sci., Vol.xl., 1897.
6. OWEN, R.—Comp. Anat. and Phys. of Vertebrates. Vol.iii. London.
7. STIRLING, E. C.—“On Some Points in the Anatomy of the Female Organs of Generation of the Kangaroo.” Proc. Zool. Soc. London, 1889.
8. VAN DEN BROEK, A. J. P.—“On the relation of the Genital Ducts to the Genital Gland in Marsupials.” Konink. Akad. van Wetensch. te Amsterdam, Proc. Sect. Sci. ix., p. 396, 1906.
9. BRASS, A.—“Beiträge zur Kenntniss des weiblichen Urogenitals-system der Marsupialen.” Leipsig, 1880.

EXPLANATION OF PLATES.

Reference letters.

bl., bladder—*b.lig.*, broad ligaments (anterior common expansion)—*cl.*, clitoris—*fm.*, fimbriæ—*l.vag.c.*, lateral vaginal canal—*l.m.v.c.*, left median vaginal cul-de-sac.—*op.*, opening of lateral vaginal canal into urogenital sinus—*pv.p.*, pseudovaginal passage—*r.m.v.c.*, right median vaginal cul-

de-sac—*r.ov.*, right ovary—*r.ut.*, right uterus—*ut.n.*, uterine neck—*ur.*, ureter—*u.s.*, urogenital sinus.

Note.—The text-figures are tracings of Figs.4-12, and each is numbered according to the figure from which it is taken. Figs.4-12 are reproductions of photo-micrographs of sections, taken with Leitz's apparatus, using incandescent gaslight.

Plate xxvi.

Sarcophilus satanicus.

Fig.1.—Female urogenital organs of adult, from dorsal aspect ($\times 1$).

Fig.2.—Genital organs of 65 mm. mammary foetus (female), from the dorsal aspect ($\times 2$).

Fig.3.—Mammary foetus, measuring, in greatest length, 65mm. ($\times$ about $1\frac{1}{2}$).

Plates xxv.-xxxv.

Figs.4-12.—See explanations in the text, and also text-figures.

The Meeting concluded with an exhibition of very interesting lantern-slides, shown by Mr. A. R. McCulloch, illustrating the experiences of a naturalist during a recent visit to the New Hebrides.

SPECIAL GENERAL MEETING.

DECEMBER 21ST, 1910.

Mr. C. Hedley, F.L.S., President, in the Chair.

Business: to elect an Auditor for the forthcoming audit, *vice* Mr. F. H. Rayment, F.C.P.A., who is eligible for re-election; and who is recommended, by the Council, for election (in accordance with the provisions of Rule xvi.).

No other nominations having been received, the President declared Mr. F. H. Rayment duly elected.



Flynn, Theodore Thomson. 1911. "Contributions to a knowledge of the anatomy and development of the Marsupialia. No. i. The genitalia of *Sarcophilus satanicus* (female)." *Proceedings of the Linnean Society of New South Wales* 35, 873–887. <https://doi.org/10.5962/bhl.part.25564>.

View This Item Online: <https://www.biodiversitylibrary.org/item/21738>

DOI: <https://doi.org/10.5962/bhl.part.25564>

Permalink: <https://www.biodiversitylibrary.org/partpdf/25564>

Holding Institution

MBLWHOI Library

Sponsored by

MBLWHOI Library

Copyright & Reuse

Copyright Status: NOT_IN_COPYRIGHT

This document was created from content at the **Biodiversity Heritage Library**, the world's largest open access digital library for biodiversity literature and archives. Visit BHL at <https://www.biodiversitylibrary.org>.