

II. *On the Life-History of a remarkable Uredine on Jasminum grandiflorum, L.*  
(*Uromyces Cunninghamianus, nov. sp.*). By A. BARCLAY, M.B., Bengal Medical  
Service. (Communicated by G. MURRAY, F.L.S.)

(Plates XLIX. & L.)

Read 16th January, 1890.

WHILE on a visit to the small village of Sairi, twelve miles from Simla, but at a considerably lower elevation than the latter (about 4000 feet above the sea-level, Simla being about 7000 feet), I found on the 28th and 29th August, 1886, several bushes of *Jasminum grandiflorum*, a wild plant growing in great profusion on the outskirts of the village, largely attacked by an æcidial fungus, which apparently at that time was nearly over, but has since proved to be one of exceptional interest. In 1887 I obtained the first specimens from nature on the 15th July—a few leaves with a few immature patches. The æcidial patches were bright yellow, and were found on the flowers, leaves, and stems; but especially frequently on flowering heads, which were then very considerably distorted and hypertrophied. The patches on the leaves varied in size from a minute point to 4 to 5 millim. in diameter and even more (Pl. XLIX. fig. 13, and Pl. L. fig. 1); but some were larger and without definite shape, probably formed by the early coalescence of originally distinct foci of attack. One such irregular patch over the middle of a leaf, involving the mid-rib, measured for example 13 millim. in length by 8 millim. in breadth, and was deeply concave above. The patches were mostly circular, reddish in colour above, and yellow below, and were bulged either upwards or downwards, though more frequently convex above.

The peridia break through from both surfaces of the leaf, but most frequently from that surface which is convex. A single leaf bears usually from one to three patches, but as many as sixteen were counted in exceptional cases. I should here mention that only the young shoots of the present season's growth are attacked, and never the older ones; and the youngest and most tender leaves and shoots are the most extensively attacked.

The æcidial patches on young stems or petioles involved either the whole structure uniformly (Pl. XLIX. fig. 14), and in that case the whole stem or petiole was uniformly hypertrophied, or the mycelium attacked only one side, forming well-defined tumours, resembling those I have described in *Æcidium Urticæ*\*, though not nearly so large (Pl. XLIX. fig. 3). The amount of hypertrophy and distortion caused was often very considerable, and the frequent attack of young buds, which were thereby destroyed, is

\* 'Scientific Memoirs by Medical Officers of the Army of India,' part ii. pp. 29, 38, 1886.

worthy of notice. The peridium, which is white, bursts at its summit stellately, allowing the orange-red æcidiospores to fall out.

At the same time I observed that several of the patches on all the above-named parts were dark-brown instead of being reddish yellow. I at first thought these were simply shrivelled-up old æcidial patches, but an examination of them with a field lens showed that although they were evidently old æcidial patches, the peridia were not collapsed or empty, but filled with dark brown spores. I therefore carefully collected a number of these dark patches, and on my return to Simla submitted them to microscopic examination, which revealed the extraordinary fact that the old æcidial cups (peridia) now contained masses of single-celled teleutospores (*Uromyces*). Although I looked most carefully for uredo pustules, I never found any, so that I had apparently an autœcious Uredine before me, in which the formation of uredospores has been entirely thrown out, without any detriment to the diffusion of the fungus, for this was extraordinarily abundant on affected bushes.

During September the further formation of æcidia ceases, and the peridia, becoming filled with teleutospores, remain dormant until the next rainy season sets in, *i. e.* for nearly nine months, for the *Æcidium* is produced only during very moist weather.

When I first found this fungus the season was too far advanced to attempt any cultivation experiments, but I preserved the teleutospores I had gathered for use during the following year, and I lost no time in at once observing the mode of germination of the æcidiospores. And this also, as will be more fully explained later, showed that the fungus was remarkably unlike any other *Æcidium* hitherto described.

From the fact that the teleutospores are formed within the peridia, and only there, it was almost certain that the parasite was an autœcious one, but it was nevertheless desirable to put this question to experimental test, and thus beyond all doubt. I consequently began early next spring to lay the teleutospores I had gathered and preserved during the winter on the leaves of wild plants collected in the woods about Simla, and which I supposed were of the same species. To my great disappointment, none of these experiments succeeded, although cultivation showed that the teleutospores had retained their vitality perfectly, germinating in water with great freedom. I at first attributed my failure solely to the fact that my inoculations were all practised at that early time of the year on old leaves, whilst, as I have already stated, in nature only the newly unfolded leaves are attacked. At the same time I never felt certain that the host with which I experimented was identical with the host I found bearing the *Æcidium* at Sairi, although superficially there appeared to be no difference between them, except that the leaves of the latter are thicker than those of Simla plants. I therefore sent specimens of the host I was experimenting with to my friend Dr. D. Prain, of the Calcutta Botanic Garden, who confirmed my doubt by naming the species *J. officinale*, L. Fortunately, very early in spring I collected some cuttings from bushes of Jasmine near Sairi, and two of these took root in pots kept in a sheltered place. These cuttings were carefully selected and were quite free from any previous attack. They put out a few delicate new shoots early in August, which unfolded several leaves later. The cuttings had been

carefully protected from exposure to normal attack, although there was little need for this precaution, as the parasite does not occur in Simla, keeping well to the deep valleys below. Upon these leaves a few teleutospores were placed, and to my great pleasure two typical æcidial patches were produced, which, after running a normal course, went on to the formation of teleutospores in the cups which had originally borne æcidiospores, thus completing the whole cycle of development.

Owing to the unfortunate mistake I made in confusing *Jasminum officinale* with *J. grandiflorum*, I had no further opportunity of confirming this single experiment by others, the season for experiment having passed by. During the following year (1888) I was absent from India, and the investigation had to lie over until my return. Since then I have succeeded in numerous instances in producing æcidial patches with sporidia, and this relationship is established beyond all doubt. The mistake, however, which I made in confusing hosts is not without interest, showing how extremely selective some species of the Uredineæ are in the choice of their hosts. *J. officinale* is very nearly related to *J. grandiflorum*\*, and yet numerous and prolonged efforts to produce the *Æcidium* on it failed entirely. I may also mention that another species of Jasmine, *J. humile*, L. †, harbours an entirely different *Æcidium*. So that the three common species of Jasmine in this neighbourhood are sharply distinguishable from one another as hosts of the Uredineæ. A knowledge of this fact, it is conceivable, might be of use to systematists in deciding the specificity of a disputed plant. Should the question arise whether our common Simla *J. officinale* is merely a variety of *J. grandiflorum*, the fact that a well-defined parasite will readily select the one to grow upon, while it will have nothing to say to the other, would possibly influence a decision.

I had personally met with the parasite only at Sairi, but a servant of mine, living in a low-lying valley near Simla, but in a different direction, seeing me interested in this "blight," brought me several shoots collected near his village, as densely attacked as any I had seen at Sairi. The fungus appears therefore to be common in the deep valleys about Simla, *i. e.* at elevations of about 4000 to 5000 feet, though it never comes up to the elevation of Simla. I have not been able to ascertain the extent of its distribution downwards towards the plains; but at one village at the foot of the hills, where this species of Jasmine is abundant, I saw no trace of it. It would thus appear, on the insufficient data available, that in vertical distribution this fungus is remarkably limited.

Transverse sections through affected portions of the stem show that mycelial invasion is mainly limited to the cortical parenchyma; but at a few points some hyphæ may be seen entering the margin of the central pith by way of the medullary rays (Pl. L. fig. 2).

The main seat of invasion is therefore the cortical parenchyma, and this tissue, when invaded, is greatly hypertrophied. In the transverse section of an affected stem about 3.25 millim. in diameter, I noted that whilst the depth of the normal layer of cortical

\* See descriptions in Sir J. D. Hooker's 'Flora of British India,' iii. p. 603.

† 'Journal of the Asiatic Society of Bengal,' vol. lvi. pt. ii. p. 363 (1888).

tissue, from the epidermis to the margin of the central circle of fibrovascular bundles, was 0.25 millim., it was from 0.88 millim. to about 1 millim. opposite the centre of the teleutospore beds. Further, in the unaffected parts of this tissue isolated small fibrovascular bundles (leaf-traces) may be seen, but in affected areas these have almost entirely disappeared; so that between the bases of the fruit-bodies (peridia) and the central fibrovascular system there is a uniform mass of hypertrophied cortical parenchyma cells. These cells are much enlarged, for whilst the normal cells in transverse section measure about  $29 \times 19 \mu$  or  $16 \times 12 \mu$ , the cells amongst the mycelium measure up to  $76 \times 63 \mu$  or even more. These hypertrophied cells, in transverse section, are round or oval in outline; but between æcidial cups they are elongated, measuring about  $113 \mu$  in length by  $31.5 \mu$  in breadth (Pl. XLIX. fig. 15). Between these elongated cells the mycelial filaments may be seen in great abundance. Although the mycelium gains entrance sparingly into the central parenchymatous tissue of the stem, it is not perennial.

When sections are made through young æcidial patches, all the peridia will be found to contain æcidiospores only; but in somewhat older patches it will be seen that, whilst the central peridia contain teleutospores, the marginal ones contain only æcidiospores, and a few intermediate between these will be seen to contain both, though in the last case neither spores in their fullest development (Pl. XLIX. fig. 16). When the production of æcidiospores ceases within a given peridium, the whole layer of basidia appears to be forced upwards by the developing bed of teleutospores—in other words, there is no concurrent growth of æcidiospores and teleutospores in any peridium; but, on the other hand, there is no pause between the cessation of the production of æcidiospores and the development of teleutospores. The exact way in which a substitution of teleutospores for æcidiospores takes place is as follows:—When a sufficient number of æcidiospores has been formed in a given peridium, the centre of the hymenium producing them is upheaved, and very shortly broken through by the developing teleutospores. A section through the middle of an æcidial cup at this time shows, therefore, a crop of young immature teleutospores, flanked on either side by old æcidiospores (Pl. XLIX. fig. 16). The crop of teleutospores increases very rapidly radially, and so quickly throws off the whole hymenium which bore the æcidiospores that in many sections, while a more centrally placed peridium in a patch may be seen bearing teleutospores only, the adjacent peridium may still be full of æcidiospores. Thus teleutospore formation is not only centrifugal in each peridium, but is also so in respect of the whole of the peridia on a patch of invasion.

The teleutospores are much greater in size than the æcidiospores, and the peridia, when they come to contain them, increase much in breadth. A young æcidial cup filled with ripe æcidiospores was found to measure 0.189 millim. in diameter, and one in the same preparation, containing old æcidiospores, 0.315 millim. in depth and width, whilst an old cup with mature teleutospores measured 0.31 millim. in depth and 0.548 millim. in width. These measurements show, therefore, that there is also a centrifugal development in each peridium from first to last.

In addition to this difference in shape, the peridium filled with teleutospores differs also markedly in having a hymenium consisting of long parallel stalks, about  $95\ \mu$  in depth, instead of the short basidia of the æcidiospores (Pl. XLIX. figs. 15 and 17).

**SPERMAGONIA.**—Spermogonia are present as usual in the early stages of development of the first crop of æcidial patches—that is, those produced by the sporidia; but they are by no means numerous, and soon all traces of them disappear. These structures are entirely absent from the patches formed later by the æcidiospores. I have never seen them in any of the numerous sections I have made through secondarily produced æcidial patches. They are of the usual form and structure, with a tuft of paraphyses protruding through their mouths to the extent of about  $44\ \mu$ . The spermogonium measures about  $145\ \mu$  in depth and width. Before these organs are produced considerable hypertrophy has already taken place in the host's tissues. For example, the normal thickness of the leaf-blade was in one case found to be  $157\ \mu$ , whilst in the spermogonial stage it was  $409.5\ \mu$  and in the æcidial  $567\ \mu$ . They are usually borne on the lower or convex side of the leaf-patch.

**PERIDIUM.**—This consists of a single layer of cells, each thickened on one side, the outer side, and bevelled at the upper and lower ends (Pl. XLIX. figs. 5 and 18). The upper bevelled end of each cell overlaps the lower end of the cell immediately above it. The cells measure about  $26 \times 19\ \mu$ , the thickened outer side being 3 to  $4\ \mu$  in depth.

**ÆCIDIOSPORES.**—These are round, or more rarely oval, pale yellow bodies, abstricted serially in rows as usual, and measuring on an average  $16\ \mu$  in diameter. Externally they are beset with minute tubercles (Pl. XLIX. fig. 4). When placed in water they germinate freely, immediately after ripening, the contents within a few hours becoming vacuolated prior to the emergence of germ-tubes (Pl. XLIX. fig. 5). The subsequent phenomena are, however, very remarkable, and unlike those of any other æcidiospores with which I am acquainted. The germ-tube, which is quickly emitted, soon acquires the appearance of a promycelium, as in the case of *Endophyllum*, but does not actually assume the character of one, as it never produces sporidia. After the germ-tube has attained a length of about  $35\ \mu$  it divides into two nearly equal parts, and each part now forms a long sterigmatous branch (Pl. XLIX. figs. 6, 7). That from the upper cell emerges almost always from the extreme end of the germ-tube, but sometimes from a point to one side of the end; whilst that from the lower cell emerges usually from a point a little below the septum. The exact position of this lower sterigmatous branch is, however, more variable: it sometimes emerges from a point near the spore, sometimes from a point just under the septum. The length of these sterigmatous tubes varies greatly: in one case the upper was found to be about  $60\ \mu$  long and  $2\ \mu$  in diameter, while the lower one was a little longer. The coloured contents of the spore wander into the germ-tube, and the empty spore-walls are then readily seen to be studded with minute tubercles. I carefully observed many water cultivations, but never saw, either there or upon a leaf-surface, any sporidia formed at the ends of these sterigmatous branches. These sterigmatous branches enter directly into the tissue of the host, and there form another mycelium, commencing the life-cycle over again.

TELEUTOSPORES.—These are brown single-celled bodies (*Uromyces*), usually distinctly thickened at the free end, through which a germ-pore may often clearly be seen. They may be scraped off their beds without much difficulty, breaking off with a portion of stalk adhering to them. On an average they measure, when just moistened,  $36 \times 20 \mu$  but individual measurements varied from  $26 \times 24 \mu$  to  $44 \times 18 \mu$ . The mean thickness of the wall of the spore is  $2 \mu$ , but at the free end where it is thickened it measures 6 to  $8 \mu$ . Most of the spores are oval and symmetrical, but a few are asymmetrical, with the thickening to one side. In some a nuclear space is clearly defined in the midst of granular protoplasm. The spores, as a rule, do not germinate immediately after ripening, although in a very few cases I did observe such germination. After a winter rest, however, they germinate freely in water, emitting a promycelium of the usual characters, dividing by septa into three cells usually, but sometimes four. I have observed the germination of these spores from early spring to July, when in nature they attack the newly-formed leaves. In April they germinate feebly and slowly; in May still only a few germinate, and that slowly; even in June some halting in germination may be observed; but in July germination is very speedy.

The diameter of the promycelium is about  $8 \mu$ . Each cell usually produces a sporidium at the end of a sterigma, which is about  $14 \mu$  in length and  $2 \mu$  in diameter. The sporidium is oval, and very often displays two vacuoles, one at each end; it measures from  $12 \times 8 \mu$  to  $14 \times 10 \mu$ . The sporidia germinate quickly, forming secondary sporidia, sometimes even before they become detached from the promycelium (fig. 12, Pl. I.). The germ-tube of the primary sporidium is somewhat stouter than the sterigma, measuring usually  $3 \mu$  in diameter. The secondary sporidium is generally about the same size as the primary; in one case, carefully measured, it was found to be  $14 \times 10 \mu$ , exactly the same as the primary sporidium which gave rise to it. I noticed that very soon after the æcidial attack had established itself the old teleutospores of the previous year lost vitality, and were no longer capable of germinating—*i. e.* during September.

Since my return to Simla, in 1889, I have been able to confirm the one successful experiment, above mentioned, in which the æcidium was produced with sporidia. On the 5th June I placed some sporidia on the young tender leaves of two plants, (*a*) a twig cut off under water and kept in a glass box outside, and (*b*) a small rooted plant in a pot kept under a glass shade in my laboratory. The sporidia were obtained thus:—Some teleutospores were scraped off on the 3rd June, and floated on water in a watch-glass, which was then kept in a moist atmosphere. On the 5th a fairly large number of sporidia could be seen with a microscope. This water was placed on the leaves of the two plants. On the 12th (7 days), (*b*) showed two leaflets distinctly attacked, and a few days later seven distinct centres of attack. Unfortunately the plant got injured, and the shoot bearing these æcidial patches died off on the 4th July, just as a number of æcidia were about to emerge. The leaves of (*a*) similarly disclosed several foci of attack, which, however, did not proceed to any æcidial formation, as, being merely cut twigs, they withered soon after initial patches were formed. Again, on the 15th June, I placed

sporidia similarly obtained, and in the same way, upon a potted plant in a glass forcing-box outside, and on the 21st (6 days) eighteen distinct foci of attack could be counted. These went on in due course to complete development. Again, I inoculated similarly a small plant growing in the open air, in my garden, on the 5th July, and on the 10th I noticed several distinct spots of attack, which ultimately ran a normal course. Attack is therefore very rapid. I could give the details of other experiments; but these are, I think, sufficient to prove that the parasite is autœcious.

The next question in the life-history of the fungus, which presents itself for consideration, is the fate of the æcidiospores. It was of course probable that they re-attacked the same host, and experimental evidence shows that this is the case. And, indeed, the natural history of the fungus pointed strongly to this result, for after a plant has become attacked in the first instance by sporidia from over-wintered teleutospores, and some æcial patches have been thus formed, the subsequent spread of the fungus is extraordinarily rapid, leading irresistibly to the conclusion that it must have been due to attack by the numerous æcidiospores liberated. Here, then, we have a marked case of the assumption by æcidiospores of the function of uredospores, and the consequent non-necessity for the production of the latter. We have, therefore, two directions in which we may look for the throwing out of uredospores from the developmental history of the *Æcidium* *Strobilanthis*\*, and (b) where, as in the present case, the æcidiospores assume this function. On the 23rd July I dusted some recently unfolded leaves of Jasmine on a twig, the end of which had been cut off under water, and then kept in a moist atmosphere under a glass shade in my laboratory, with æcidiospores. On the 30th I noticed several distinct spots of attack. As these could not go on to complete development, I dusted some leaves on the latter date, both young and old, of a potted plant outside with æcidiospores, and covered the whole with a glass shade. On the 3rd August very numerous spots of attack could be detected on all the young leaves, and all these went on to further complete development. Attack, then, with these spores is even more rapid than with sporidia. The most striking thing in such experiments with æcidiospores is the immense attack of the host (Pl. L., fig. 1), and the extreme rapidity with which it takes place. But although the young leaves were thus largely attacked, the older darker leaves resisted completely. I could give the details of other experiments in this direction also, but they would be, I think, superfluous.

In conclusion, I will offer a few remarks suggested by the peculiarities of this fungus. These are mainly three: (a) the production of teleutospores within the peridia; (b) the assumption of a distributive function by the æcidiospores; and (c) the very peculiar germination of the æcidiospores.

The unusual site of teleutospore-formation forms a link with *Puccinia Berberidis*,

\* 'Scientific Memoirs by Medical Officers of the Army of India,' pt. ii. p. 20.

Montagne, where, as figured by de Bary \*, these spores are formed immediately outside the peridium by the same mycelium. This suggests the view that primarily teleutospores were always formed within peridia, and that in course of evolution they were thrust immediately outside (*Puccinia Berberidis*), then further away (*Uredo Behenis*, &c.), and lastly were produced on separate mycelia, as happens at the present time with the great majority of these fungi.

The assumption of a distributive function in so marked a degree by the æcidiospores is, I believe, illustrated for the first time by this species. It renders the production of uredospores superfluous, and we have consequently none.

With regard to the third peculiarity, that, namely, of the germination of the æcidiospores, this naturally suggests affinities with *Endophyllum*. If the latter may be regarded as a starting-point in the evolution of the Uredinæ, we have here a connecting-link with others. Instead of the æcidiospore forming a regular promycelium, with sporidia, we have, so to speak, an abortive promycelium, stopping short of the production of sporidia, but attacking with a sterigmatous branch, the result being alike in both cases, the immediate reproduction of a similar spore. In the case of *Endophyllum*, however, the mycelium is perennial, whilst it is certainly not so in the species under consideration. Instead of persisting through an unfavourable time in mycelial form, the latter produces, as we have seen, a resting spore, which must be regarded as an advance, inasmuch as the production of such a spore must be both more economical and more certain for the preservation of the species than a perennial mycelium. Assuming for the moment that the Uredinæ have started from a form like *Endophyllum*, then it is conceivable that an evolutionary course something like the following may have taken place :—

1. First stage æcidiospores only, but behaving like teleutospores in producing sporidia; preservation of species by perennial mycelium. (*Endophyllum*.)
2. The same: but with a view to a more economical method of preserving the species, the formation of a second kind of spore with resting properties. The production of sporidia, which only wastes time as far as a distributive function is concerned, is being relegated to the teleutospore. (The species now under consideration would be an example.)
3. A more marked separation of distributive and preservative function in these two forms of spores, the latter still continuing to assist in distributing, but mainly subserving a preservative function (teleutospores which germinate at once after maturing, as well as after a rest, e. g. *Æ. Strobilanthis*).
4. A complete separation of these functions, with the production of a third form of spore (uredo) to aid in distribution. (Including the majority of species whose life-histories are known.) Here, except for special reasons (mostly unknown), a perennial mycelium becomes unnecessary.

\* 'Botanische Zeitung,' 1879, no. 48, t. 10.

5. At first the same portion of the same mycelium produces both spores (the species under consideration).
6. Later, on the principle of the physiological distribution of function, separate portions of the same mycelium form the separate spores (through *P. Berberidis* to the more ordinary forms).
7. Later still, to aid in the struggle for existence, where the distribution of species becomes important, separate mycelia produce separate spores (most autœcious species).
8. With increasing struggle for existence, heterœcism with increased necessity for aid in distribution, *i. e.* for the production of uredospores (most heterœcious species).

But, as I have said, there are grounds for thinking that *Endophyllum* should not be regarded as the starting-point in this evolution. If the æcidial fructification had been the most essential, it is not probable that it would have been thrown out in any species; and yet in *Puccinia Collettiana*, as I have shown\*, and as others have shown, I believe, in other cases, this has happened, and no vestige of it is left. Indeed, as Dietel points out†, the only spore-form, which, as far as we know, is invariably present, is the sporidium, the product of a teleutospore, and Brefeld has advanced strong arguments for regarding every other form of spore as subsidiary.

*Endophyllum*, in this view, must be regarded as an aberrant branch, and it would perhaps be more correct to look upon the Jasmine æcidium as tending in the same aberrant groove. It is conceivable that, if the mycelium acquired a perennial habit, as has been acquired by *Endophyllum*, the formation of teleutospores would become unnecessary, and would therefore cease to be formed. In that case our fungus would become practically an *Endophyllum*.

It is worthy of remark that in this species the sporidium and the æcidiospore are physiologically almost equivalent, as each produces a like mycelium, with this difference only, that while the mycelium produced by a sporidium bears spermatia, that produced by an æcidiospore does not. As this is the second Uredine in which I have observed this peculiarity I would draw particular attention to it. I first noticed it in the life-history of *P. Collettiana*‡. In this species also the sporidia form mycelia bearing spermogonia; but the mycelia produced by primary uredospores, though like the former mycelia in every other respect, bear no spermatia. If further investigation should show that the same occurs in all similar cases (members of the groups *Brachyuromyces*, *Brachypuccinia* and *Uromycopsis*, *Pucciniopsis*, Schröter), this would give additional support to Brefeld's view that spermatia and sporidia are spores of a like kind (conidia) differing from the remaining forms of spores in this order (chlamydospores).

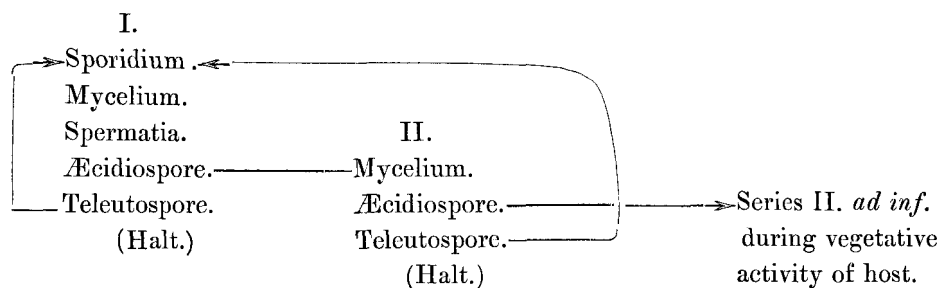
The whole life-cycle of the species under consideration may begin with the æcidiospore, ending with a sporidium, or, beginning with a sporidium, end with a teleutospore;

\* 'Scientific Memoirs by Medical Officers of the Army of India,' pt. v. 1890, pp. 87-91.

† "Beiträge zur Morphologie und Biologie der Uredineen," a series of seven papers in the 'Botanisches Centralblatt,' xxxii.

‡ *Loc. cit.*

but in the cycle beginning with an æcidiospore no spermatia are formed. The cycles may be represented graphically thus :—



We have here, then, a new species, with very distinctive features, and I propose naming it *Uromyces Cunninghamianus*, after my friend Dr. D. D. Cunningham, F.R.S., whose beautiful researches in India in this as in other branches of botanical science are well known. Of the several groups into which the *Uromyces* have been divided, this species would come most nearly under *Uromycopsis*, Schröter; but it bears no trace whatever of uredospores.

*UROMYCES CUNNINGHAMIANUS*, n. sp.; æcidiis in soros orbiculares aggregatis, hypophyllis vel cauliculis, orbicularibus, minutis, 4–5 mm. diametro, inferne rubro-aurantiacis, superne rubris; æcidiosporis albo-luteis orbicularibus vel ellipsoideis,  $16\mu$  diametro, tuberculatis; pseudoperidiis albis, apice stellatim dehiscentibus, et strato uno cellularum externe incrassatarum compositis,  $26 \times 19\mu$ ; spermogoniis  $145\mu$ ; uredosporis defectis; teleutosporis vero in æcidiorum soris erumpentibus demum omnino eorum sedes possidentibus, atro-fuscos in soros congestis, ellipsoideis, fuscis, apice libero incrassato, levibus, se cum pedicelli fragmento avellentibus,  $26 \times 24$ – $44 \times 18\mu$ ; sporidiis ovalibus,  $12 \times 8$ – $14 \times 10$ , sæpe sporidia ipsis gerentibus.

The æcidia are produced only on newly unfolded leaves, and the mycelium causes considerable hypertrophy of the host's tissue. The æcidiospores produce a germ-tube divided into two parts by a septum, each forming a narrow sterigma. The spermogonia are produced only by mycelium formed by sporidium, are not numerous, and are of the usual form and structure.

Habitat in leaves, stems, and floral parts of *Jasminum grandiflorum*, Linn. N.W. Himalayas.

## DESCRIPTION OF THE PLATES.

### PLATE XLIX.

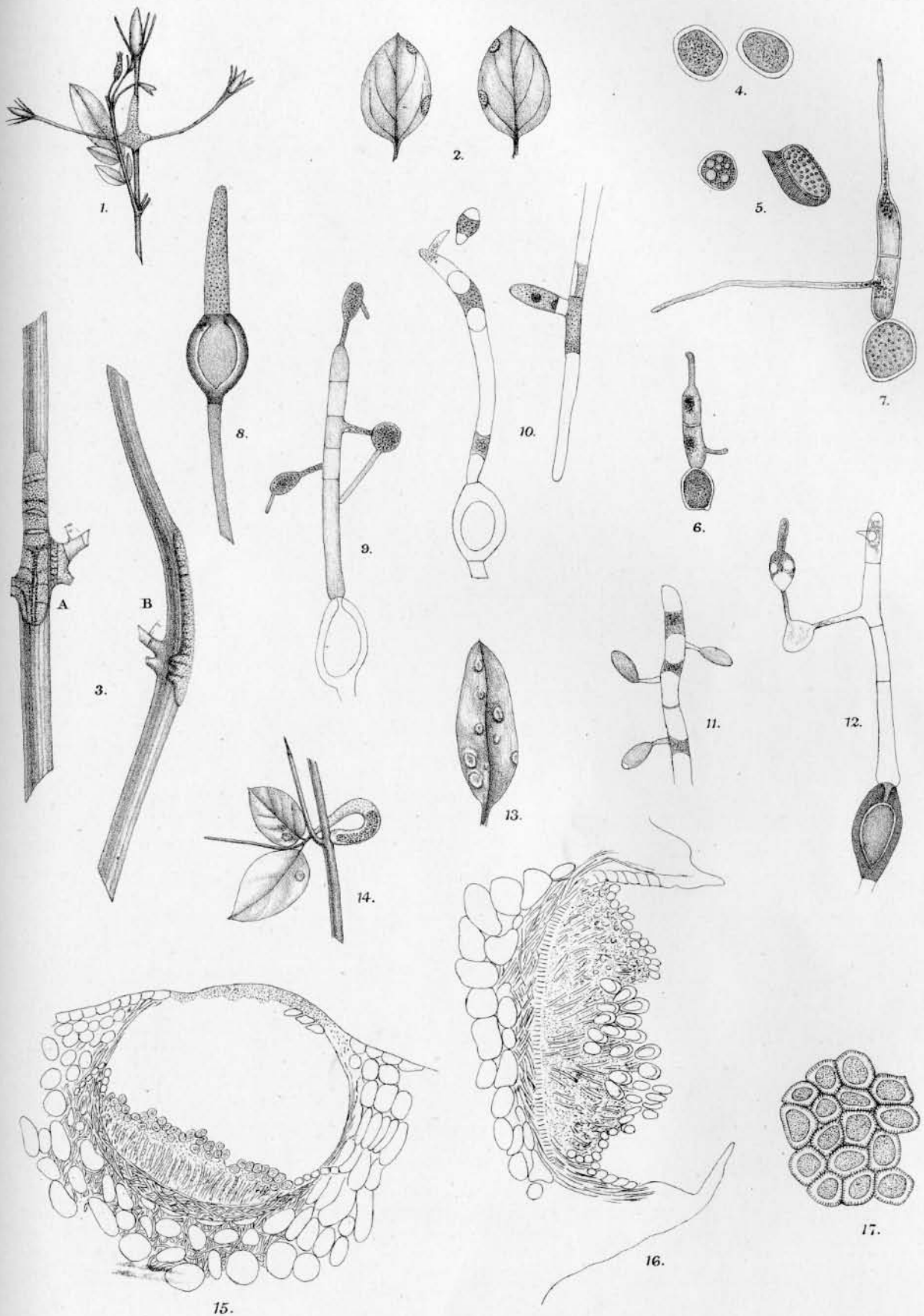
Fig. 1. Terminal end of flowering shoot, showing three buds and a node attacked. In teleutosporic stage. Nat. size.

Fig. 2. Upper and lower surface of leaf, with two isolated patches of invasion. In teleutosporic stage. Nat. size.

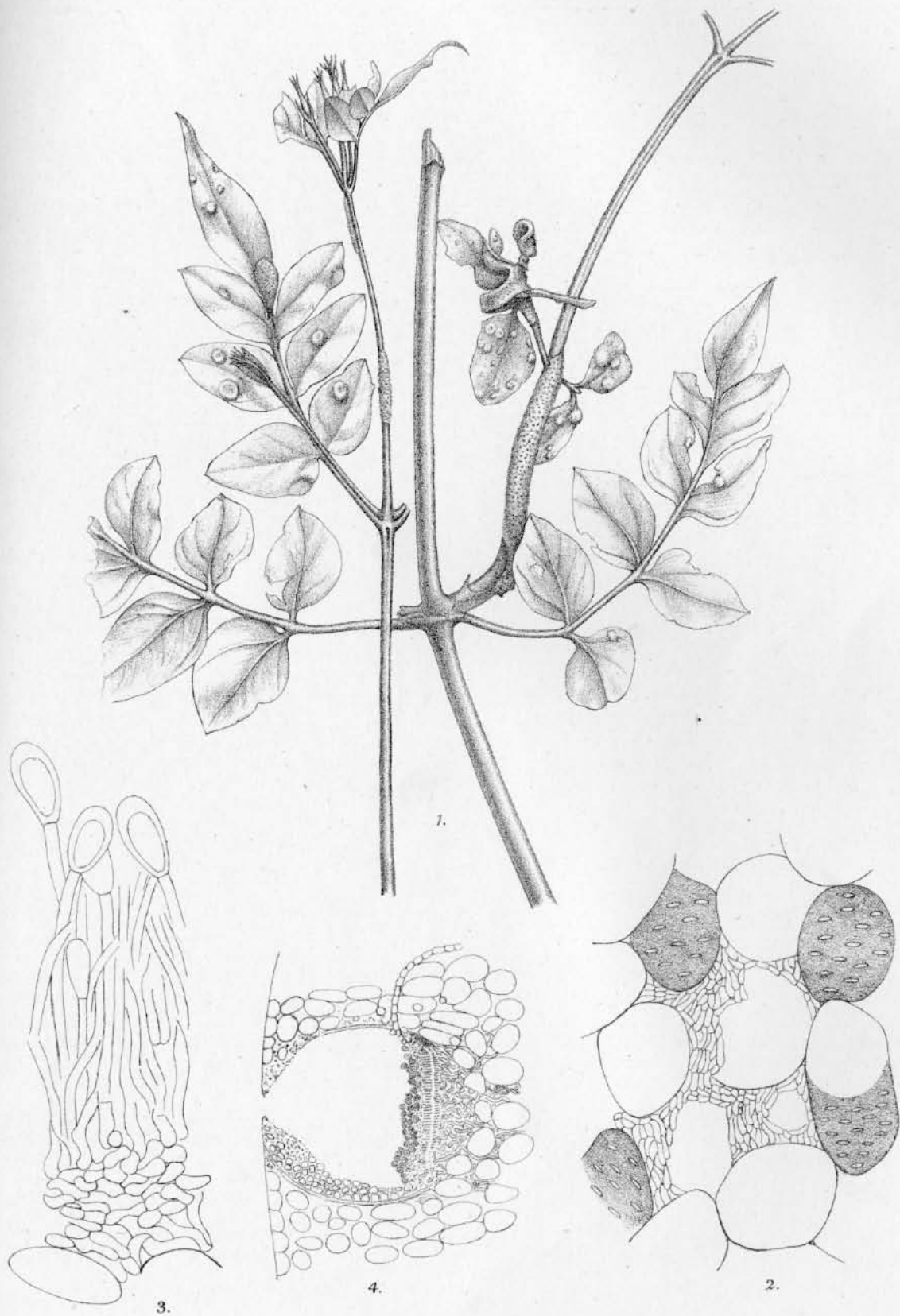
- Fig. 3. A and B. Two views of same stem attacked, showing localized hypertrophy. In teleutosporic stage. Nat. size.
- Fig. 4. *Æcidiospores*.  $\times 350$ .
- Fig. 5. Vacuolated *æcidiospore*, and isolated peridial cell.  $\times 350$ .
- Fig. 6. *Æcidiospore* germinated; sterigmatous branches still small.  $\times 350$ .
- Fig. 7. Ditto, with sterigmatous branches fully developed.  $\times 350$ .
- Fig. 8. Teleutospore, showing commencing germination.  $\times 350$ .
- Fig. 9. Teleutospore completely germinated, bearing three sporidia, all of which have emitted germ-tubes while still attached to promycelium.  $\times 350$ .
- Fig. 10. Showing abnormal promycelial development. At (b) abnormal formation of sporidium.  $\times 350$ .
- Fig. 11. End of promycelium bearing three sporidia.  $\times 350$ .
- Fig. 12. Promycelium bearing a sporidium which has formed a secondary sporidium while still attached.  $\times 350$ .
- Fig. 13. Leaf showing several points of attack; *æcidial* stage. Nat. size.
- Fig. 14. Showing petiole generally attacked, with much hypertrophy and distortion; mostly in *æcidial* stage, but showing commencing teleutospore formation. Nat. size.
- Fig. 15. Section through the peridium containing teleutospore bed, with elongated stalks (basidia).  $\times 140$ .
- Fig. 16. Section through peridium showing commencing teleutospore formation; *æcidiospores* on either side.  $\times 140$ .
- Fig. 17. Peridial cells seen flat.  $\times 350$ .

## PLATE L.

- Fig. 1. From photograph showing shoot gathered at Sairi largely attacked in *æcidial* stage; the result of attack by *æcidiospores*. Nat. size.
- Fig. 2. Portion of section through attacked stem from central pith, showing mycelial invasion.  $\times 350$ .
- Fig. 3. Portion of section through peridium containing teleutospores.  $\times 350$ .
- Fig. 4. Section through peridium in *æcidial* stage; short layer of basidia as compared with fig. 15.  $\times 140$ .



UROMYCES CUNNINGHAMIANUS, Barclay.



UROMYCES CUNNINGHAMIANUS, Barclay.