THE LIFE-HISTORY OF Puccinia ruelliae (B & Br) ON RueLLIA PROSTRATA POIR.

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Sydow (1904) has recorded five species of Puccinia on the genus Ruellia. He divided these into two groups one having verrucose-walled teliospores and the other smooth-walled. Coming under the former are P. longiana on R. tuberosa; P. lateripes (Berk. and Rav.) on R. ciliosa; P. ruelliae-bourgei (D. and H.) on R. bourgei and P. ruelliae on R. strepens and R. prostrata. P. paranahyba which has smooth-walled teliospores is recorded on R. longifolia. The rust on R. prostrata was from Ceylon while the others were from the Americas. Butler and Bisby (1931) have mentioned the occurrence of P. lateripes on Ruellia spp. at Pusa (Bihar) and P. ruelliae on R. longifolia (at Cawnpore) and R. prostrata in various parts of India. Arthur (1934) has given six species of Ruellia serving as hosts for P. ruelliae in the U.S.A. Further he has reduced P. lateripes and P. ruelliae-bourgei to the status of synonyms of P. ruelliae. This appears to be the correct view as there are no significant differences between the different species belonging to the group possessing verrucose teliospores.

Kellerman (1903) conducted successful infection experiments with P. lateripes on R. strepens. Arthur (1906) was able to produce infection on R. ciliosa and R. strepens with teliospores of P. lateripes. P. ruelliae is very common on R. prostrata in and around Coimbatore in South India. It is a macro-cyclic and autecious rust, all the stages being formed on the same host in the course of one and the same season. The succession of the different spore forms and their methods of development were closely studied. Advantage was taken of the occurrence of all the spore forms to follow the sequence in the development of the different stages by inoculation experiments. The present studies were carried out on R. prostrata and the results are recorded in this communication.

R. prostrata is a common perennial weed in South India which persists throughout the year in shady situations, but the rust is in evidence at
Coimbatore mainly from August to March of the succeeding year. During the south west monsoon in July and August the weed puts on fresh growth. The uredio and telial stages are seen in profusion at the beginning of this period. The lower leaves of the plant are the first to be infected. These sori are usually not found on the youngest leaves.

_Uredia._—These are amphigenous and brown in colour. The sorus develops sub-epidermally. Later the epidermis is lifted up and finally ruptured. The hyphae of the fungus are intercellular, sending prominent twisted haustoria into the host cells. The uredial primordium forms below the epidermis and from this the urediospores are produced. These spores are stipitate, spherical to sub-globose, echinulate and yellowish brown in colour. Two equatorial germ pores are seen. Two nuclei are distinctly visible. The spores measure 22×23μ.

![Fig. 1. Young urediospores (×300).](image)

![Fig. 2. Teliospores (×250).](image)

_Telia._—Soon after the formation of uredia, telia are formed often associated with uredia. Teliospores may develop either in urediosori mixed with urediospores or in separate sori. These are amphigenous, confined to the leaf-blades but more numerous than the urediosori and scattered all over the surface. They are dark chestnut brown, surrounded by the whitish flakes of the ruptured epidermal tissue. The development of the telia is sub-epidermal as in the uredia. Teliospores are pedicellate, the pedicel being hyaline and attached to the spore variously, _i.e._, to the base or obliquely to the side. The pedicel breaks easily leaving a portion of varying length persistently attached to the spore. Teliospores are two-celled chestnut brown, thick-walled, verrucose, sub-globose with rounded ends, slightly constricted at the septum and with one germ pore in each cell. The germ pore of the apical cell is at the top while in the lower cell it is placed variously. The spores measure 24×36μ.

Teliospores germinate readily without a period of rest. As a matter of fact, fresh spores collected in August, November and December exhibited a higher percentage of germination than those from specimens collected in
March. Maneval (1922) found that the time required for the germination of teliospores varied with the period in which germination tests were made. It is less than two days in May, less than eight days in December, but over eighty days in September under conditions prevailing in Columbia. Under Coimbatore conditions, germination is evident in 12 to 24 hours when fresh spores are floated on drops of water on slides and kept inside a moist chamber. Germination was visible in hanging drops also in the spores which floated near the margin of the drops, while those which were immersed in water did not germinate. This indicates the necessity for aeration for teliospore germination. The promycelium emerges out through the germ pore. It is stout, hyaline and four-celled, the septa developing in the upper half of the promycelium. From each cell a sterigma is developed and on this an oval or round hyaline basidiospore is formed. Basidiospores commence germination even while they are attached to the basidium.

![Fig. 3](image)

**Fig. 3.** (a) Germinating teliospore showing the germination of basidiospores (×100). (b) Germinating teliospore (×100).

**Experiments and Observations**

Inoculations were made on healthy seedlings of *Ruellia prostrata* specially raised for the purpose and free from rust. Fresh teliospores were removed from sori and placed on drops of distilled water on the leaves or a suspension of fresh teliospores in sterilized water was brushed with a sterile camel-hair brush over the surface of the leaves, petiole and stem. The pots containing the seedlings were kept covered over with bell-jars to provide favourable conditions for infection and to prevent natural infection. Suitable control plants were also kept under similar conditions. Ten to twelve days after inoculation, groups of pycnia were evident on the inoculated leaves, petioles and stem. Younger leaves, petioles and stems were readily infected, while mature lower leaves or older portions of the stem...
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failed to take infection. This is explained by the fact that basidiospores are able to penetrate only younger tissues as the entry is effected by piercing the epidermal cell wall. On the leaf-blades circular swollen areas develop which are convex either towards the upper or lower surface with a corresponding depression on the opposite side. The areas become studded with very minute red or yellowish brown pycnia on both sides. Pycnia are formed in abundance on the portions of the petioles and stem which are swollen as a result of hypertrophy. They are globose or oval, sub-epidermal, paraphysate and measure on an average $110 \times 190 \mu$. The paraphyses and the spore stalks are elongated, uninucleate and light orange in colour. From the apex of each conidiophore, oval to oblong pycniospores ($4.5 \times 6.0 \mu$) are formed. These are hyaline or light pink in mass and float in the nectar which collects at the mouth of the pycnium. The paraphyses are prominent and project out of the ostiole. Aecia develop in the midst of groups of pycnia found on the leaf veins, petioles and swollen portions of the stem. The aecia are not formed on the interveinal portions of the leaf-blade though pycnial groups are present in these areas. The infected portions become swollen due to the hypertrophy of the tissues. In the leaf, the palisade cells of the mesophyll become enlarged. In the petiole and the stem the cortical cells are very much enlarged in the infected portions and contribute to the formation of the swellings. In severe cases of infection, clusters of branches like 'witches broom' develop from the nodes and numerous aecia are studded on the stem of these abnormal branches (Plate I, c).

![Fig. 4.](image)

**Fig. 4.** (a) Pycniospores ($\times 150$). (b) Section of a portion of a young aecium ($\times 300$). (c) Germinating aeciospore ($\times 150$).

Aecia.—These are cupulate with a nearly cylindrical more or less white peridium with jagged edges, which soon become recurved. The aeciospores in mass are coloured deep brown. They are elliptic to irregular and thick-walled, the thickening being more pronounced at the apex and base,
prominently verrucose and measure, 22 × 30 μ. One conspicuous germ-pore is present.

The primordium of the ãecium is first composed of a plectenchymatous mass of hyphae formed three or more cell layers below the epidermis and which force the host cells apart. The host cells separate and in the resulting space the ãecium develops. Its development is similar to what is observed in many of the cupulate ãecia. The binucleate nature of the cells is evident in the basal cells of the hymenium and also in many of the hyphal cells found much below the hymenium (see Fig. 4 b). The peridium is made up of one layer of cells which forms a continuous envelope extending from the sides and arching over the young ãecium. Later, the host tissue is pushed up and eventually ruptured exposing the ãecium and the ãeciospores. The ãeciospores are developed from the basal cells in chains. The ãeciospores alternate with intercalary cells which shrivel and disintegrate, thus facilitating the dismemberment of the ãeciospores from the chains. Æeciospores are capable of immediate germination. One germ tube is produced from each spore which grows out through the germ pore. Viability of the ãeciospores is gradually lost with age. Fresh ãeciospores germinate in twelve hours but ãeciospores from specimens which had been kept between drying sheets and stored in envelopes at laboratory temperature (26–28° C.) for three months did not exhibit any signs of germination even after two days under optimum conditions. In December, suspensions of fresh ãeciospores were brushed on the surface of leaves of healthy Ruellia seedlings and these were covered over with bell-járs to provide humid conditions. In fifteen to twenty-two days uredia developed on the inoculated leaves. Unlike the pycnia produced from basidiospores, the urediosori were formed only on the older lower leaves and failed to infect younger leaves at the apices of the shoot. The entry of germ tubes from ãeciospores being through the stomata, the older leaves are readily infected. In the course of another week, teliosori were also observed on the same leaf. The control plants were free from infection.

The above studies have shown that P. ruelliae is a macro-cyclic, autœcious eu-form of rust exhibiting 0, I, II, and III stages. Starting with the teliospore the life-history has been followed up through all the other stages. During these studies it was found that during one season this rust can complete two or more cycles on this host.

**SUMMARY**

The life-history of *Puccinia ruelliae* on *Ruellia prostrata* was studied by inoculation experiments. It is a macro-cyclic and autœcious rust, all the
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stages being formed on the same host in one and the same season. The succession of the different spore forms and their method of development were closely studied. Advantage was taken of the occurrence of all the spore forms to follow the sequence in the development of the different stages by inoculation experiments.

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REFERENCES

A. Section through a pycnium showing paraphyses and the pycniospores.
B. Section through an æcium showing the hymenial layer, peridium and the æcio-
spores.
C. Showing cluster of branches like "witches broom" and the numerous æcia
studded on the branches.