STUDIES ON THE UREDINALES OCCURRING IN AND AROUND ZARIA

BY

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THESIS APPROVAL

This thesis by SEKAR, Vanaja meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University and is approved for its contribution to scientific knowledge.

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D E C L A R A T I O N

I hereby declare that the whole of the work now submitted as a Thesis for the MASTER OF SCIENCE degree in the Department of Biological Sciences, Ahmadu Bello University, Zaria is the result of my investigation (except where reference is made to published literature and where assistance is acknowledged) and has not been part o any presentation for any other qualification.

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ABSTRACT

In the present study, which is the first of its kind in northern Nigeria, an attempt was made to collect as many rusts as possible from both cultivated crops and wild hosts in and around Zaria, to identify the hosts as well as the rust organisms.

All the rusts studied except two namely, Puccinia cynodontis and Ravenclia sp. nov. appeared on their respective hosts in one or more of the spore forms between the months of June through November. The two rusts P.. cynodontis and Ravenelia sp. nov. were collected throughout the year. The highest incidence of both uredinia and telia was observed during September and October Only.

Thirty four different host plants were observed to be infected by 30 species of rusts. Among the hoet families collected, the Gramineae was the most highly infected with 48 % of the total rusts. In all, 10 families of the hosts were infected by one or more of the rust organisms.

Out of 30 rust species studied, 15 belonged to the genus Puccinia, **six** to Uromyces, two to Ravenelia, one each to Mclampsora and Phakopsora. Four of them belonged to the form genus Aecidium and one to Uredo. Five of the 30 rust species identified were found to be of economic importance and these included Puccinia substriata var. penicillariae on Pennisetum americanum, Puccinia sorghi and Puccinia polysora both on Zea mays, Puccinia arachidis on Arachis hypogea and Uromyces appendiculatus var. appendiculatus on Vigna unguiculata

Out of the 30 species of rusts studied, *24* had uredinia, 21 telia and Tour aecidia. The life cycle of the rust Puccinia substriata var. penicillariae connecting its graminaceous host Pennisetum americanum and its aecial host Splanum melongena (Solanaceae) was carried out for the first time. The life cycle of a microcyclie rust, Puccinia hoterospora on Sida urens and S. ova ta was also completed.

A majority of the rusts collected (18 out of 30) were new records for Nigeria, these are Puccinia sp. nov. on Hyparrhenia rufa, Uredo sp.nov. on Imperata cylindrica, Ravenelia sp. nov. on Albizzia chav .leiri and Tcphrosia bracteolata, Uromyces sp. nov. on Albuca sudanica and Aecidium sp. nov. on Moaechma ciliaturn. Rottboelia exaltata was recorded as new host for Puccinia versicolor. Other new records for Nigeria were Aecidium jasmini, A. hartwegiae, A.mitrocarpi, Puccinia cyperi, P„romagnoliana, P. ellisiana, P. oahuensis, p. eritraeensis, P. versicolor, P. leucadis, and P. laterita.

During the course of the studies, 17 of the rusts collected were found to be parasitised by the hypcrparasites Darluca filum and one by Juborculina costaricana The perfect stage of D. filum namely, Eudarluca australis was found infecting the rust Puccinia polysora.

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ABBREVIATIONS, SYMBOLS AND GLOSSARIES

i. Abbreviations used in Tables :

DPX : Distrene plasticizer xylene

E : Equatorial

GP : Germpore

MS : Mesospore

O : Obscure

P : Paraphyses

S : Scattered

µ : Micron (one-thousandth of a millimetre)

iii Symbols used in Tables

\+ : Present - Absent

iii. Glossaries

Autoeciuos : Requiring only one host for the complete life cycle

Cysts : Sterile inflated cells encircling the teliospore-head in the genus Ravenelia

Demicycle : Having pycnia, aecia and telia in the life cycle, the uredinia wanting

Diorchoid : 2-celled and with septum longitudinal

Discoid : Flat and circular resembling a disk

Echinulate : Having small pointed processes or spines

Erumpent : Bursting through the surface of the substratum

Fascicle : A little group or bundle

Gametophytic: The state in the life cycle which bears pycnia and aecia

Heteroecious: Requiring two not closely related hosts in the life cycle

Hyaline : : Transparent or nearly so; translucent; colourless

Macrocyclic : Having all the spore forms in the life cycle or at le:

Mesospore : one type of binucleate spore in addition to teliospore
A one-celled teliospore associated with two-celled teliospores in the genus Puccinia

Microcyclic : Having only pycnia and the telia in the life cycle or with pycnia obsolete

Ovoid : : Like a hen's egg with narrower end at the top

Obovoid/obovate: Inverseley ovate/ narrower at the base

Paraphyses : Sterile structures occurring within or around sori

Sporophytic : The diploid or asexual phase in the life cycle

Verrucose : Having rounded, wart-like markings

Verruculose : Delicately verrucose

Umbo : A central swelling like the boss at the centre of a shield

I. INTRODUCTION

Fungi as agents of decay play an essential role in maintaining the earth's biosphere. Fungi are of ancient lineage and were plentiful during the Devonian period (some 400 million years ago) in association with the first land plants as both saprophytes and parasites (Ainsworth, 1976). The sudden appearance of the fruit bodies of large fungi and moulds have always attracted attention. As a result, there is a large non-scientific literature on fungi. It was the subject of much folk-lore and they were mentioned frequently in poetry, drama and prose from the time of the classical writers of Greece and Rome.

The term 'Mycology' (also mycologist) seems to have been first used in 1836 by Berkeley although he used at a later period 'fungology' in his well-known book, 'Outlines of British Fungology' (Berkeley, 1860). After the invention of microscope in seventeenth centuary, Hooke, Leeuwenkoek and Malpighi gave the first description of some common microfungi (Ainsworth, 1976). Stimulated by the researches of Pasteur in 1876, the brewing industries employed mycologists and the founding of the Carlsberg Laboratory in Copenhagen. Up to the middle of the last century, the mycologists were mainly confined to Europe. Later, the advancement spread from France and Germany to United States and geographical scatter of mycologists at present is world wide with the greatest number in north America and Europe with a sizeable concentration in India, Pakistan and Japan.

It was Micheli (1729) who published the classification of the fungi in his book 'Nova plantarum genera'. Linnaeus (1753) was the first to use the binomial nomenclature in the text and index of Olandska och Gothlandska Resa and published his first edition

of ' Species Plantarum '. Persoon (1801) introduced the concept of the hymenium and he believed that basidiomycetes bore asci. It could be seen that he kept the discomycetes apart from hymenomycetes. He brought the rusts and smuts together in the Dermatocarpi. Almost all the hundred genera and subgenera he recognised are universally accepted genera even today. Fries (1827), in his first published volume ' Systema Mycologicum ' classified fungi into four classes. An evolutionary approach to the taxonomy of fungi was made by de Bary (1866). In the preface to the first edition of his text book, he offered a general classification of fungi which closely resembles that widely accepted today. He published the second edition of his book in 1884 which corresponded even more closely to that most generally followed during the next hundred years.

Rust disease caused by members of the Uredinales has been known since the pre-historic period. Mention about the rust was made early in Hebrew-writing. The ancient Romans believed that two Gods namely, Rubigus and Rubigo were responsible for the rust disease and they celebrated annual festivals known as the Robigalia from about 700 B.C. to appease the Gods to avoid rust epidemics (Littlefield, 1981).

Sydow and Sydow (1902 - 24) contributed valuable information to the classification and cataloguing of rusts of the world in their ' Monographia Uredinarum ' in four volumes. Berkeley (1860) during the period 1857 - 60 contributed valuable information on the rust flora of oriental countries. Saccardo (1882 - 1931) enumerated the rusts of the world in his books ' Syllogue Fungorum ' in 26 volumes. Plowright (1889) published the British Uredineae and Ustilagineae. Later, McAlpine (1906) published the rusts of Australia giving their structure, nature and classifi ation. Butler and Bisby (1931)

During the second half of the 19th century , the problem of sexuality in rusts attracted the attention of many uredinologists. Meyen (1841) suggested that the spermagonia and the aecia were the male and female organs. Cytological studies by Poirault and Raciborski (1895) showed that the cells of the Uredinales frequently were binucleate which divided in pairs. Sapin-Trouffy (1896) observed that in a macrocyclic rust, the teliospore is always uninucleate and gives rise to four uninucleate sporidia on germination. He further found that the mycelium bearing the aecia, the aeciospores and the urediniospores to be binucleate. The nuclear fusion occurred in the mature teliospore. Blackman (1904) confirmed Sappin-Trouffy's (1896) findings and illustrated the nuclear migration between the cells of the developing aecia to give the binucleate condition.

Craigie (1927) announced his demonstration by monosporidial infection of sunflower that Puccinia helianthi L. was heterothallic. He further concluded that the sporidia were of two types (+) and (-) and that when adjacent, the fusion occurred and the aecia were formed. He further illustrated the fusion of pycniospores with fluxuous hyphae (Craigie, 1933)

Rusts have long been defined as obligate parasite, unable to grow separately from the host plant. But, Hotson and Cutter (1951) were the first to grow rust fungus on synthetic medium. Williams et al., (1966) reported the axenic culture of Puccinia graminis f. sp. tritici by direct seeding of aseptic urediniospores on to agar-mineral medium containing yeast extract plus sucrose. This work was repeated by other workers mainly in North America and Europe with good success (Scott and MacLean, 1969; Scott, 1976; Wolf, 1974).

The economic status of plant rusts has been known for a very long time. White pine blister rust caused by Cronortium ribicola Fisher indigenous to Siberia, spread to Europe in the late 1800s and destroyed forests of the 5-needled pine, including the Waymouth pine in Great Britain. Soon after the rust spread to Europe from Asia, it was introduced on nursery stock into North America, where it eventually extended across the continent (Littlefield, 1981).

More than two hundred million hectares of the world's crop land are devoted to the production of its most important food crop wheat (F A O , 1979). On a major part of this acreage, in the vast wheat areas in Russia, Poland, Argentina and the southern Great Plains of North America and to a great extent in the wheat-producing areas of India, Pakistan, China and Australia, the most destructive disease of wheat is brown rust. In 1922, the disease was epiphytotic in North America and Europe and almost absent in India. In 1924, it was epiphytotic in North America and inconsequential in Australia and in European Russia (Chester, 1946).

In Europe, the most significant and widespread rust pathogen of wheat is Puccinia striiformis Westend, which causes the disease known as yellow rust. In England, in an epidemic year, up to 50 - 60 % reduction in yield was observed in susceptible varieties. In the Netherlands, 70 % of the 1956 winter crop was destroyed by yellow rust. In United States, losses up to 75 % were recorded in commercial fields in 1960 and 1961. Sporadic epidemics of stem rust have cost North American farmers countless billions of dollars. In 1916, the disease was estimated to have destroyed 300 million bushels of wheat in United States and Canada. In 1935, rust epidemics destroyed 135 million bushels in Dakota and Minnesota.

Serious epidemics of stem rust in Kansas and Nebraska caused losses of 35 and 32 million bushels in 1961 and 1962 (Littlefield, 1981).

The epidemics of Puccinia recondita Rob. and P. striiformis Westend in 1971-72 and 1972-73 in north west India caused losses of 0.71 and 1.37 million tonnes of wheat respectively, out of a total production of 11.5 and 13 million tonnes. An isolated but severe epidemics of these rusts was recorded during November, 1973 in Sanchore, Rajasthan, India when nearly one third of the entire crop was destroyed and not even harvested. In 1978 - 79, a large area in MadhyaPradesh India suffered losses of 60 - 75 % (Joshi et al., 1980).

Waterhouse (1936) estimated the total annual loss from cereal rusts in the world to be $ 500 million, of which average annual loss of more than 40 million occurred in Canada during 1930, $ 15 million in India during 1931, $ 150 million in Russia in 1932, DM 418 million in Germany during 1916, $ 10 million in New South Wales and 191 million bushels in Argentina during 1925. The loss caused by Puccinia substriata var. penicillariae (Speg.) Ramachar and Cumm. on Pennisetum americanum L., P. purpurea Cke. on Sorghum species, P. polysora Underw. and P. sorghi Schw. is considerably high.

Likewise, the losses caused by rust diseases to plantation crops have been well documented. Coffee was the major source of income in Sri Lanka and other colonies in Southern Asia. The widespread and rapidly advancing epidemics of coffee rust caused by Hemileia vastatrix Berk. and Br. in the 1870s and 1880s devastated coffee plantations. They were later replaced with tea plantations. The coffee rust spread to African plantations where it has been estimated to cause an annual loss of 4.5 million kilogrammes of coffee beans in Kenya alone (Littlefield, 1981). In 1960, it was introduced

into South America from Africa, presumably by transatlantic winds. Commercial crops such as groundnut (Arachis hypogea L.), cowpea (Vigna unguiculata L.) and soybean (Glycine max L.) suffer heavy yield losses due to rust infection (Bromfield, 1971; Cummins, 1978).

Among the fruit crops, grape vine, apple, plum and strawberry are good examples in which considerable losses in yield were experienced due to rust infection (Butler and Jones, 1955; Wormald, 1946). It was reported that some of the fibre crops like cotton and flax were also attacked by rust disease (Butler,1918; Sundaram,1964)

Man has always been 'fighting with nature' to reduce the losses caused by rust diseases. Several methods have been adopted, but breeding for rust resistant varieties has yielded spectacular results. Prior to breeding for rust resistance, fungicidal control was attempted in many countries during the last centuary (Millardet, 1885; Frear, 1948; Evans, 1968; Marsh, 1977). Among several chemicals used, sulphur was successfully used in controlling plant rusts (Horsfal, 1945). Kightlinger and Whetzel (1926) by applying sulphur dusts achieved yield increases of 31 % in wheat. Besides suphur, many other fungicides like borax, picric acid, lithium salts, lime suphur, maleic hydrazide and various sulfonamides were used in earlier years.

Straib (1941) sprayed green house plants at varying times after inoculation with a number of organic substances. Picric acid was more effective as a fungicide than ortho- or para- toluol sulphanomides, acridin or 0.2 % borax. The acidity of picric acid seems to be chief factor in toxicity to urediniospores. Picric acid and acridin each at 0.1 % killed all rust spores tested in 24 hours at 20°C or 14°C. More recently the organic fungicides, both the

sulphur containing dithiocarbamates as surface protectants or eradicants have been used economically for cereal rust control (Horsfall and Diamond, 1959 - 60). Copper oxide provides effective control of coffee rust in plantations.

Eradication of alternate hosts has been a more widespread practice in the past. The oldest example of eradication of an alternate host is that of barberry eradication programme initiated in France in 1660. In North America, an extensive barberry eradication programme, eventually covering about 1 million square miles (2.6 million Km^2) was initiated during the World war I. The area included 19 States in the United States and 3 adjacent provinces in Canada. By eradicating the barberry bushes in the United States, an annual saving of over $ 30 millions was recorded (Stakman and Harrar, 1957). Barberry eradication was initiated in Denmark in 1903, in Bavaria in 1950s and in Ireland in 1960s (Littlefield,1981).

Rusts in many cases are highly specialised into biologic races. Long before Mendel, agriculturists and early plant breeders were empirically crossing plants and making selections to obtain superior lines. Some hybrids developed by Knight in England were free from'blight'. Farrer (1898) produced numerous rust resistant wheat hybrids in Australia.

Eriksson (1899) made extensive studies on the physiologic races. This was further continued by many workers notably Freeman and Johnson (1911), Stakman et al. (1933). Biffen and Engledow (1926) were the pioneers to breed disease resistant varieties. They demonstrated that resistance to yellow rust was inherited in a Mendelian fashion. In segregation, the progeny of a

cross between a very susceptible and a resistant variety, disease resistance was shown to be controlled by a single recessive gene. Later, resistance was shown to be conditioned more commonly by dominant genes. Soon extensive breeding programmes were initiated in many countries and numerous rust resistant cultivars on a variety of plants were evolved. To date, some 35 single genes for wheat stem rust resistance and some 30 for flax rust resistance have been identified (Nelson, 1973).

Breeding for disease resistance included the search for wild species which possess natural resistance for many diseases (Vavilov, 1935). One other source is mutation breeding using either chemical or radiation treatment. This gave positive results in many countries including Argentina, India, Pakistan, United States and in Europe. The use of ' Multiline varieties ' adopted by a number of International Team of Breeders and Pathologists resulted in the release of several agronomically superior cultivars.

It is of primary importance to document the occurrence of economically important diseases, their epidemiology and estimating the probable losses before launching any research programme to control. Such an excercise has been adopted in several developed countries. However, in a sizeable number of developing countries an authentic record giving the details of the economically important diseases including rusts are still wanting.

Records on the incidence of plant rusts have been published in the past from several countries in Africa. Among them, the records from Sudan by Tarr (1955) included 10 genera of rusts consisting 52 named species, out of a total of 383 species of fungi belonging to 175 genera collected till that time. Piening (1962) published a check

list of fungi recorded from Ghana in which 120 named species of rusts were included. From Tanzania, Riley (1960) published the first check list of fungi. Later Ebbels (1972; 1973) published 2 lists in which 75 species of rusts were listed in the first list and 25 species in the second. The Kenyan fungi were listed by Robinson (1962), in which he included 25 host species affected by 26 species of rusts. An exhaustive list of rust fungi was published by Kranz (1965) from Libya in which 40 named species of rusts on 48 hosts were listed. From Rhodesia, Hopkins (1939) published the first list of fungi in which he included 69 species of rusts. Hansford (1943) published the rusts of Uganda.

The Nigerian fungi were listed by several authors. West (1938) was perhaps the earliest to publish a check list in which 6 rust fungi were included. Later, Waterston (1952) published the list of diseases of economic plants including 5 rusts on Triticum vulgare, Vigna unguiculata, Sorghum species and Zea mays. Recently, Bailey (1966) published a check list of plant diseases in Nigeria among which 46 species belonged to Uredinales. This was up dated by Emechebe et al. (1980). Eboh and Obike (1977) were the first to make taxonomic study of the Nigerian rusts. They confined their studies on grass hosts in and around Nsukka. Later, Eboh (1978; 1981) supplemented the list adding several rusts on grasses and dicots. Brian (1981) carried out a taxonomic survey of rusts in the Milliken Valley. He was able to collect in all 14 rust species infecting 10 hosts.

OBJECTIVE

In Nigeria, although the rusts of a few cultivated crops including cowpea, pearl millet, guinea corn, wheat and groundnut were listed in the past by several workers no attempt was made to collect the rusts occurring in northern Nigeria, classify and arrange them in a systematic form. Similarly, no attempt has been made to study the life cycle or the epidemiology of the rusts recorded in this part of the country.

The present studies,are, therefore, aimed in collecting and identifying (as far as possible) all the rusts occurring in and around Zaria on cultivated as well as wild hosts.

Epidemiology of the rusts collected during the investigation were studied. All the rusts collected from various hosts were identified, arranged according to their family and a suitable key was provided to identify them. They were further arranged according to their host families, genera and species.

The process of germination of various spore stages were studied as soon as they were collected. Studies on the life cycle of economically important macrocyclic rust namely, Puccinia substriata var. penicillariae infecting pearl millet (Pennisetum americanum) and the commonly occurring microcyclic rust Puccinia heterospora infecting several species of Sida were undertaken.

Hyperparasites on rusts have not been properly recorded in Nigeria in the past. Therefore, attempts were made to collect as many hyperparasites as possible from the rusts collected during the present studies and identify them.

II. MATERIALS AND METHODS

1. Survey and Collection

Rust infected plant specimens were collected from localities in and around Zaria at an interval of 3 - 4 weeks commencing October, 1982. Field observations were made recording the general conditions of the affected parts of the plants and the stages of the rust growth based on macroscopical examination. Photographs of the plant parts showing typical symptoms of rust infection were taken in the field. Representative specimens were collected, kept between blotting papers, pressed well and dried before they were used for laboratory studies. The specimen used for spore germination studies was kept in polythene bags and preserved in a refrigerator at 5 °C to maintain the materials in a relatively fresh condition for more than a week.

2. Identification of rust

Free hand sections were made from the fresh specimens having different stages of rust pathogen and examined under the microscope. The sections were mounted in lactophenol-cotton blue and the slides were labelled. Fresh spore mounts of the available stages of the rust were made in clear lactophenol for further examination. The rust pathogens were identified consulting relevent literature.

3. Sectioning, Fixing and Hardening

Pieces of host specimens containing the rust pustules were killed and fixed for 12 hours by immersing them in Formalin Acetic-Alcohol (FAA) prepared according to the following formula.

Ethyl alcohol (95 %)	50 ml
Glacial acetic acid	5 ml
Formaldehyde (37 - 40 %)	10 ml
Distilled water	35 ml

4. Dehydration and clearing

The leaf samples fixed and hardened were dehydrated by passing through series of ethyl alcohol grades ranging from 70 % to absolute alcohol leaving the samples in each grade for 30 mts before passing it to the next grade. After dehydration, a graded series of chloroform alcohol mixer as given below was used. The materials were transferred from absolute alcohol to specimen tubes containing ⅓ chloroform plus 2 /3 absolute alcohol for 30 mts. Finally, the materials were transferred to pure chloroform in which two changes were made at an interval of 30 mts each (Sass, 1958).

5. Infiltration with paraffin wax

A teaspoonful of molten paraffin wax was poured into the cold chloroform and allowed to solidify as a layer on top of the solvent. Later, the tubes were placed inside the oven at 35°C with the lid open in order to allow gradual infiltration of the wax into the tissues of the specimens. More molten wax was added. This process was continued till a thin layer of undissolved wax remained on the top of the solution. The under surface of the layer of paraffin eventually developed a translucent, crystalline appearance. When this stage was reached, the solvent was obviously saturated with paraffin at 35°C. At this stage, the oven temperature was adjusted to 53 °C to dissolve the solidified wax. At the end of an hour, one half of the homogeneous solution was poured off and the volume was made up to the original by adding molten wax and the tubes were returned into the oven. After 4 or 5 such

partial replacements, the paraffinsolvent was poured off and replaced with fresh molten wax.

6. Casting into a mould

The molten wax containing the specimens was poured into a pre-warmed metal mould and the specimens were quickly arranged using a warm needle to avoid entry of air bubbles. The materials were arranged 5 mm apart and the mould was moved into a cold water pan and the surface was allowed to solidify. They were then submerged in water by placing some weight on it. When the wax was thoroughly cooled, the mould was discarded.

7« Microtome sectioning

Material ejnbeded in paraffin wax was cut with a rotary microtome. Cutting was accomplished with wedge action. Successive slices remained attached to each other forming a ribbon of paraffin.' The thickness of the sections was adjusted to 18 u which helped to preserve the rust spores in tact with the host tissues.

8. A fixing

A small drop of Haupt's adhesive was placed on a slide and smeared into a thin film with the finger. The slide was flooded with distilled water and pieces of ribbon about an inch long, each containing the sections of rust materials, were floated on water. The slide was then placed on a warm plate set at 55 C until the paraffin expanded and flattened. The ribbons were arranged giving proper spacing and the excess water was blotted off using a lintless filter paper. The slides were then dried by placing them on a warm plate set at 5° C.

9. Staining

Afterwards, afixed sections were dried inside the oven at 53 °C. They were coated with molten paraffin from the ribbon. The first operation before staining was to dissolve the paraffin by immersing the slide in a jar of xylene. Then as outlined in the staining chart, progressive transfer to water was made through the indicated grades of ethyl alcohol. Transfer was made quickly so that the slides did not become dry. They were then immersed into the stain (aqueous Safranin). The excess Safranin began to dissolve out during subsequent passage through 30 %, 50 %, 70 % and 95 % alcohol. The slides were then passed through the counterstain, Fast Green F.C.F. in 95 % alcohol. The slides were then dehydrated as detailed in the staining chart before they were finally transferred to xylene. They were removed from xylene and the excess xylene was wiped off using a dry blotting paper. A drop of D.P.X. (mounting medium) was placed on the section before lowering a clean coverslip on to the mounting medium, taking care that no air bubble entered. The excess resin was squeezed out around the edges or over the cover slip. The slides were dried in an oven at 53 °C for a few days.

STAINING CHART FOLLOWED

Xylene	(2 - 5 min. dewaxing)
Absolute alcohol	(2 - 5 min.)
95 % alcohol	(2 - 5 min.)
70 % alcohol	(2 - 5 min.)
50 % alcohol	(2 - 5 min.)
30 % alcohol	(2 - 5 min.)
Distilled water	(1 - 2 min.)
Aqueous Safranin	(up to 12 h.)

12. Camera Lucida drawing

'ABBE' type Camera Lucida was used to draw the different spore forms of the rust namely, uredinia, telia, spermagonia (pycnia) and aecia. Drawings of the germinating urediniospores, teliospores and aeciospores wherever possible were also made.

13. Photomicrography

Photomicrographs of different spore types as well as the germinating spores were taken either under high or low power magnification using the film ASA plus XPAN KB 17.

14. Germination of different types of spores

Fresh urediniospores, teliospores or aeciospores of the rusts collected were used to study their mode of germination. The spores were carefully removed with the help of a spear head needle from a freshly formed uredinia or aecia and were floated on drops of sterile water kept om clean sterile slides. In the case of teliospores, they were removed from well developed sori. The slides containing the spores were then placed inside petri-plates lined with moist filter papers on the upper and lower lid.. The entire unit was then kept in a dark cup board until observations on germination of the spores were over. As soon as the spores germinated, a drop of lactophenol-cotton blue was placed on them to arrest further growth as well as contamination from saprophytes. The slides were then labelled and preserved for further examination.

15. Inoculation of the host plant

Healthy test plants were raised either from seeds or vegetative parts and were kept protected from external infection till they were used for inoculation. Plants which remained healthy at the time

of inoculation were used in the experiment. Before actual placement of the spores, the leaf surface of the host plants were thoroughly washed with sterile water and were drawn gently with wet fingers before placing the spores. This was done in order to remove the waxy bloom on them so that the water drops sprayed on them would stay intact. Such treatment facilitated quick germination of the spores and early penetration of the host tissues by the germ tube. Only viable spores of the selected rust were used for inoculation. Immediately after inoculation, the plants were covered with labelled clean bell jars, the inner surface of which were also sprayed with fine droplets of sterile water to maintain high humidity. Observations on the process of infection and development of rust were made every day to study the development of the rust fungus.

Only five plants in each test hosts were used for inoculation due to their limited availability.

B. EPIDEMIOLOGY OF UREDINALES COLLECTED IN AND AROUND ZARIA

The incidence and perpetuation of plant rusts are known to be influenced by the variations of air temperature and relative humidity. A record on the monthly occurrence of various stages of the rusts studied are given in Appendix - ii.

The uredinial and telial stages of only two rust species namely, Puccinia cynodontis and Ravenelia sp. nov. were collected throughout the year in Zaria. Two other rusts namely, Puccinia heterospora and P. laterita were found to be microcyclic having only telial stage. Out of 30 rusts studied, 24 had uredinia, 21 telia and four aecia.

An analysis of the incidence of various stages of the rusts studied showed that the highest incidence of uredinia and telia was observed during September and October. The formation of uredinia was high from August through November, dropped suddenly to 66 % in December and slowly reduced to 10 % in March. The favourable months to form telia for most of the rusts studied appeared to be from August to November. Most of the rusts disappeared during the drier period from November to May (Fig. 1)

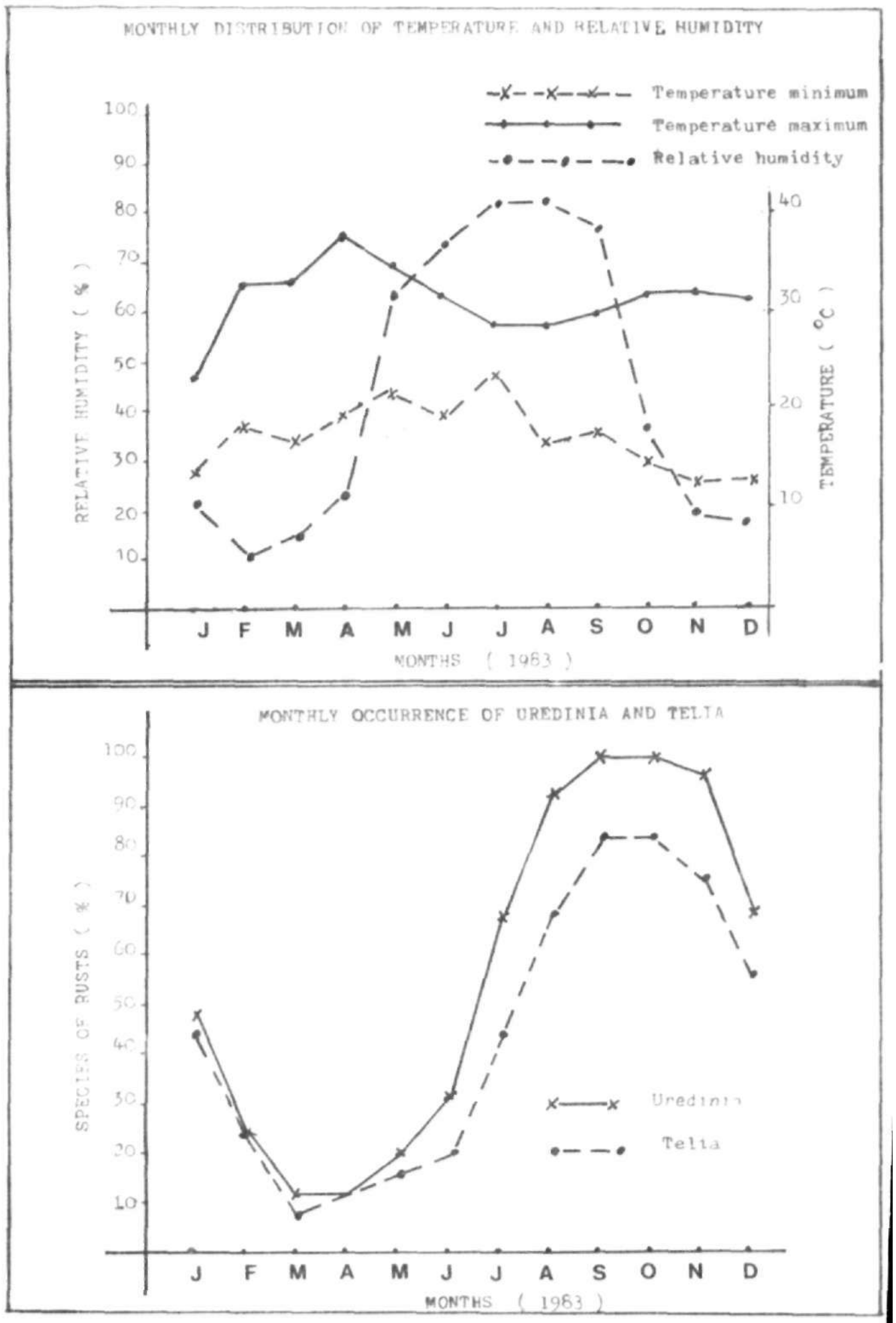


Fig. 1. Weather conditions and rust occurrence in 1983

C. KEY TO GENERA OF RUST FUNGI STUDIED

1.	Teliospores sessile	3
2.	Teliospores pedicellate	4
3.1.	Teliospores 1 celled, irregularly arranged in subepidermal crusts	Phakopsora
3.2.	Teliospores in indefinite crusts of 1 - cell thick, aecia with rudimentary peridium or none	Melampsora
4.1.	Teliospores 1 - celled only	Uromyces
4.2.	Teliospores 2 - celled but 1 - celled spores are occassionally intermixed	Puccinia
4.3.	Teliospores united both vertically and at sides forming a discoid head; pedicels formed of several strands forming a fascicle	Ravenelia

FORM GENERA

5.	Uredinia alone	Uredo
6.	Aecia alone	Aecidium

D. KEY TO RUST SPECIES BY GENERA OF HOSTS

CYPERACEAE

Cyperus

Uredinia isolated, wall cinnamon brown, surface echinulate, pores 3 (2-4), equatorial; telia not in locules, 12 µ apically, aparaphysate ..... 1. Puccinia cyperi

Uredinia confluent, thin walled, light brown, pores 2, equatorial; telia in locules, apex up to 10 µ, paraphysate ...2. P.romagnoliana

EUPHORBIACEAE

Euphorbia

Uredinia in groups, spore wall yellow, minutely verrucose, pores obscure.....3. Melampsora euphorbiae

GRAMINEAE

Andropogon

Uredinia isolated, exposed; spore wall yellow, up to 4 µ, germ pores 3 (4), equatorial; telia exposed, 2 - celled, aparaphysate, chestnut- brown, apex 5 - 10 µ .....4. Puccinia ellisiana

Cynodon and Leersia

Uredinia in streaks, wall thick upto 4 µ, yellow, pores 2 (3), equatorial; telia exposed, 2 - celled, apex up to 12 µ, dark brown .....5 P.cynodontis

Pennisetum

Uredinia patchy, open, paraphysate, spore wall thin, light brown, echinulate, pores obscure; telia covered, spores sessile, 1- celled, arranged in subepidermal crusts, loosely attached to each other .....12 Phakopsora apoda

Uredinia open, isolated, aparaphysate; spore wall thin up to 2 µ, light brown, strongly echinulate, pores 4 or 5, equatorial; telia covered, normally 2 - celled .....13 Puccinia substriata var penicillariae

Setaria and Brachiaria

Uredinia scattered, exposed, wall 2 µ thick, yellowish brown echinulate, pores 3, scattered; telia covered, 1 - celled, pedicel hyaline, contents chestnut-brown, wall uniformly thick up to 2 µ ..... 14 Uromyces setariae-italicae

Sporobolus

Uredinia patchy, covered; spore wall 2 - 3 µ, light brown, echinulate, pores 4 (3 - 5), equatorial; telia covered, 1 - celled, pedicel yellowish, wall 2 µ at sides and 6 µ at apex, chestnut-brown .....15 U.tenuicutis

Zea

Uredinia isolated, small, covered, spore wall 2 µ, echinulate, golden or yellowish, pores 4 (5) equatorial; telia covered, pedicel thin walled, yellow, spores 2-celled, wall 1.5 µ at sides, 2 µ at apex, brown ..... 16 Puccinia polysora

Uredinia large, confluent, open, spore
wall 2 µ, strongly echinulate, pores 3 (4),
equatorial, golden or cinnamon brown, pedicel
wall thin, yellow; teliospores 2 - celled,
1.5 - 2 µ at sides and 7 µ at apex, golden
brown .....17 P.sorghi

JASMINACEAE

Jasminum

Pycnia absent; aecia cupulate, spores thin,
walled, echinulate, 15 - 20 µ diam .....18 Aecidium jasmini

LABIATEAE

Leucas

Uredinia isolated, open, spores two types,
thin and thick walled, echinulate, pores 2
equatorial; telia open, pedicel coloured,
spore wall 2 µ at sides and 7.5 µ at apex,
dark brown .....19 Puccinia leucadis

LEGUMINOSAE

Arachis

Uredinia open, in groups, spore wall 2 µ,
brown, finely echinulate, pores 2 (3-4)),
equatorial; telia open, spores 2 - celled,
thin, hyaline, 2 µ at sides and 5 µ at apex,
contents yellowish .....20 P.arachidis

Albizzia

Uredinia open, scattered, spore wall
coloured, thin at sides, and 5 µ at apex
acuminate tip, contents brown at base
and deepens at apex, strongly echinulate,
paraphysate, pores 4, equatorial; telia

exposed, spores 1 - celled, compound pedicel
wall thick, dark brown .....21 Ravenelia sp. nov.

Crotalaria

Uredinia open, in groups, spore wall 2 µ,
brown, echinulate, germ pores 4, equatorial;
telia open, spores 1 - celled, surface finely
echinulate, striate markings, wall 2.5 µ at
sides, 4.8 µ at apex with umbo, golden
brown .....22 Uromyces occidentalis

Tephrosia

Uredinia open, scattered, spore wall hyaline
to light yellow, 2 µ at sides and 4 µ at
apex, densely echinulate, pores 5 - 6 ,
obscure, scattered; telia open, spores 1 -
celled, with compound pedicel, wall thick at
apex, strong spines on free surface,
cinnamon brown .....23 Ravenelia sp. nov.

Vigna

Uredinia open, scattered, spore wall thick
3 µ, light brown, finely echinulate, pores
3 obscure, equatorial; telia open,
scattered, spore wall 5 µ at sides and
up to 10 µ at apex with umbo, contents
dark brown, pedicel short, thin walled
and hyaline .....24 Uromyces appendiculatus

LILIACEAE

Allium

Uredinia isolated, covered, spores thin

walled, up to 1.5 µ, hilum prominent, pores 2, equatorial; telia covered, 1 - celled, uniformly thick walled, light brown .....25 Uromyces sp.nov.

Chlorophytum

Pycnia spherical, 96 µ diam., aecia cupulate spores echinulate, bright yellow, wall thin, verrucose, 19.2 - 36.0 x 14.0 - 20.0 µ ....26 Aecidium hartwegiae

MALVACEAE

Sida

Uredinia absent; telia open, spores mostly 1 - celled and mixed with few 2 - celled spores, pedicel sometimes diorchoidly attached, wall uniform, light brown to chestnut - brown .....27 Puccinia heterospora

RUBIACEAE

Borreria

Uredinia absent; telia in groups, open, spores normally 2 - celled, but 1 - celled often mixed, pedicel obliquely attached, thin walled, yellow, spore wall uniformly thick up to 3 µ at sides and 5 µ at apex, light brown ..... 28 Puccinia laterita

Mitrocarpum

Pycnia not seen; aecia cupulate, surrounded with marginal peridium, spores thin walled, contents bright orange, very minutely verruculose .....29 Aecidium mitrocarpi

Monechma

Pycnia subcuticular, spherical, 72 - 84 µ;

aecia cuptlate, spore wall thin, contents

yellowish, finely verrucose, 21.6 - 24 x

16.8 - 21 µ .....30 *Aecidium* sp. nov.

E. DISTRIBUTION OF RUST GENERA ON HOST FAMILIES

Thirty rust species were collected during the studies in and around Zaria. They comprised 5 genera and two form genera, the details of which are given in Appendix iii. A majority of them (50 %) belonged to the genus Puccinia, followed by Uromyces (23 %), Ravenelia (6 %), Phakopsora (3 %) and Melampsora (3 %). The two form genera namely, Aecidium and Uredo formed 12 % and 3 % respectively of the specimens collected. It is seen that Puccinia and Uromyces are the dominant genera of rusts as is the case in other countries (Ainsworth and Bisby, 1971).

The rusts were collected from 38 hosts belonging to 10 genera of which 45 % were from the Gramineae followed by Leguminosae (14%). The rest of the collections were distributed over 9 host families (Appendix-ii) In a few hosts namely, Hyparrhenia rufa and Zea mays, more than one species of rust was collected. Some rust species like Puccinia cynodontis, P. versicolor, Uromyces linearis and U. setariae-italicae were collected from more than one host. The details are given in Appendix - iv.

The distribution pattern of the rust genera as well as the host genera infected by rusts closely agree with the general pattern observed in most of the tropical countries.

1. PUCCINIA CYPERI Arthur

(Plate I; Fig. 2 a)

Occurrence:

Cyperus reduncus Hochst ex Boeck belonging to Cyperaceae is a common weed growing in cultivated fields in and around Zaria. It survives during the rainy season starting from May till the end of November. The rust was first observed on this host during the month of October, 1982. Further observations showed that the uredinia were commonly found between June and November. The telial stage was very common during the months of August through November. The host normally dries up during the dry period starting from December till the onset of rains in April - May.

Description:

Pycnia and aecia : They were not observed during the studies.

Uredinia : Rust spots amphigenous, oval to slightly irregular, isolated, initially yellowish turning brown at maturity; uredinia mostly hypophyllous, isolated, numerous, the epidermis rupture early exposing the brown powdery mass of spores; urediniospores ellipsoid or obovoid, wall uniformly thick up to 2 µ, cinnamon brown, minutely echinulate, germ pores 3 (2-4), equatorial, 16.8 - 24.0 x 24.0 - 35.3 µ; aparaphysate.

Telia : Telia chiefly hypophyllous, isolated or mixed with uredinia, epidermis rupture early exposing dark brown or blackish spore mass; teliospores 2 - celled, broadly clavate, oblong, rounded at the apex or slightly truncate, the lower cell tapering towards the pedicel, septum prominent, wall uniformly thickened at sides up to 1,5 µ, apex thickened up to

12 µ, wall smooth, contents cinnamon brown, thin walled, not collapsing, spores measure 18.2 - 26.4 x 25.3 - 41.3 µ; paraphysate.

Identification :

Several rust fungi have been recorded on the host genus Cyperus from many parts of the world the details of which are given in Table 1.

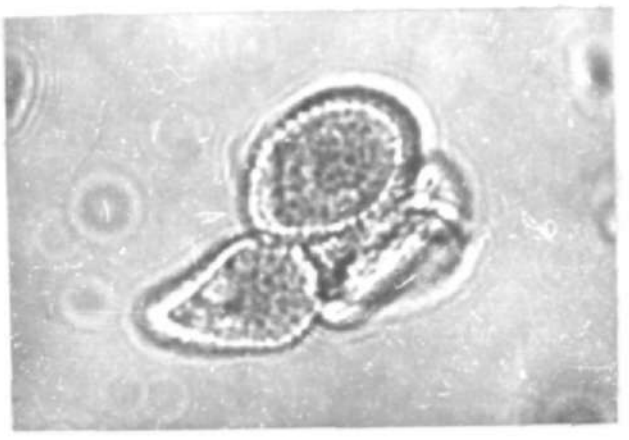
Table 1. Comparative details of rusts recorded on Cyperus species and the rust under study

Rust species	Uredinia			Telia		
	Measurements (in µ)	P	G P	Measurements (in µ)	P	MS
1. Puccinia canaliculata (Schw.)Lag.	13 - 19 x 19 - 29	-	2 E	15 - 21 x 39 - 64	+	-
2. P. romagnoliana Maire and Sacc.	12 - 22 x 19 - 28	-	2 E	12 - 25 x 28 - 48	+	+
3. P. cyperi Arth.	18 - 24 x 24 - 35	-	3 E	18 - 26 x 35 - 61	+	-
4. Rust under study	17 - 24 x 24 - 35	-	3 E	18.2 - 26.4 x 25.3 - 41.3	+	-

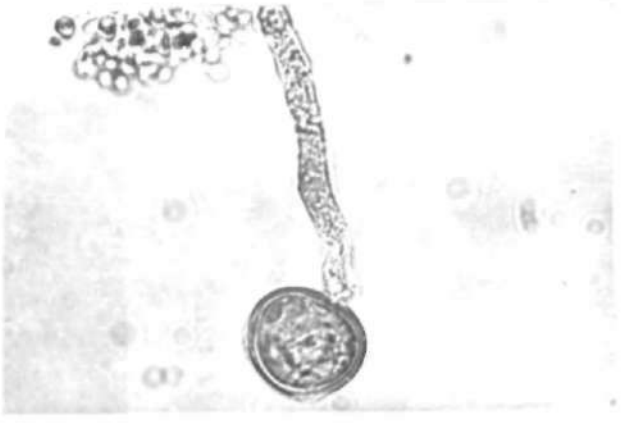
The characters of uredinia and telia as well as the spore measurements of the rust collected from Zaria on the host Cyperus reduncus very closely resemble to Puccinia cyperi described by Arthur (1891) based on the specimens collected from the United States. Puccinia cyperi is distinquished from other species recorded on the host genus Cyperus by the presence of larger urediniospores and teliospores, 3 germ pores in the urediniospore as against only 2 in other species.



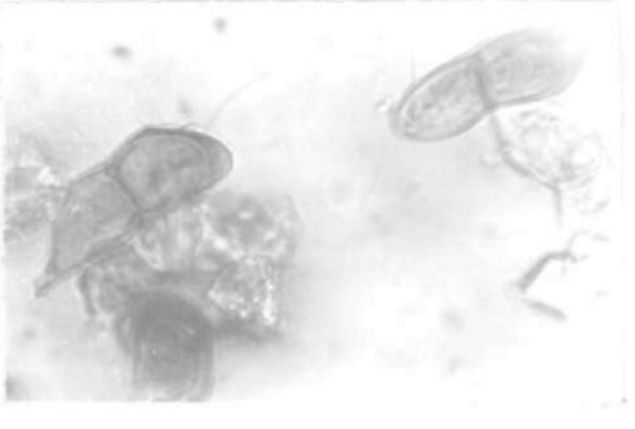
a. Infected plant



b. Urediniospores

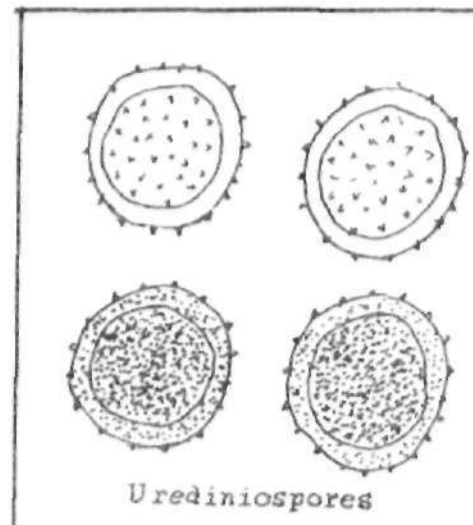


c. Urediniospore (germination)

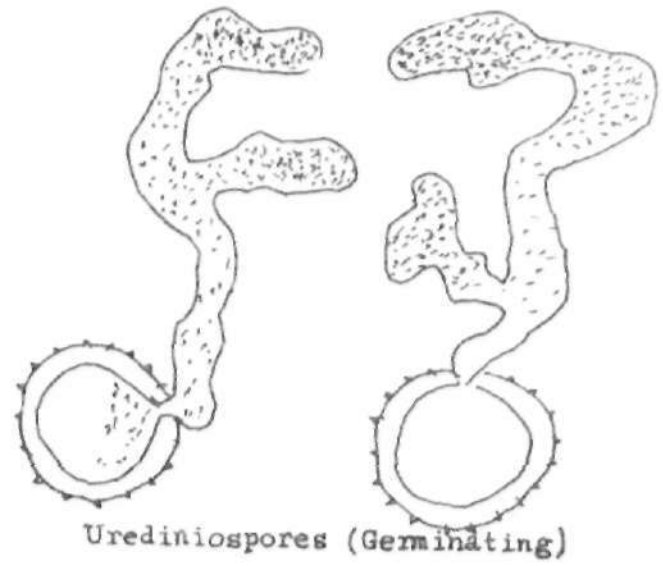


d. Teliospores

PLATE I. Puccinia cyperi on Cyperus reduncus

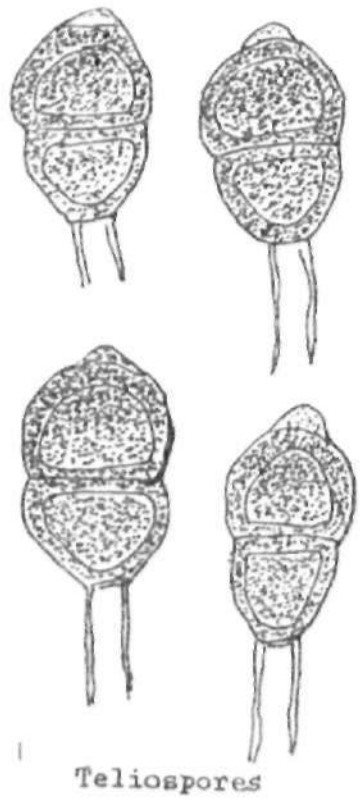


Urediniospores

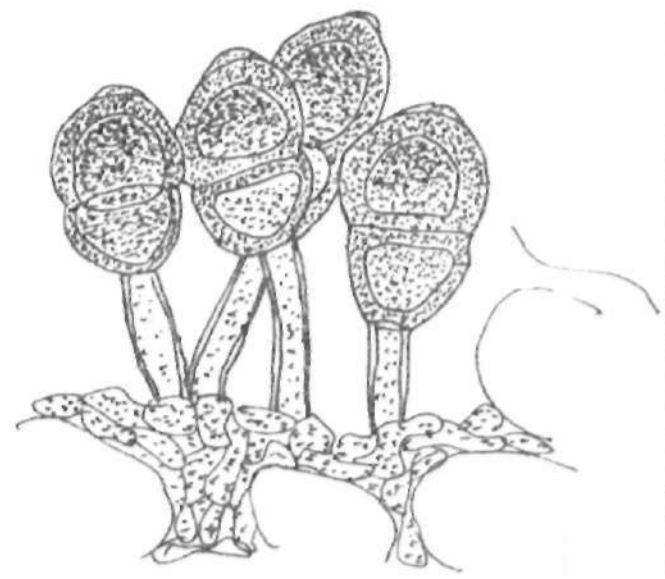


Urediniospores (Germinating)

50 μ



Teliospores



Telium (Section)

Fig. 2 A PUCCINIA CYPERI ON CYPERUS REDUNCUS

Puccinia cyperi has been recorded on the genus Cyperus from different parts of the world especially in tropical regions. It is also recorded from several of the African countries. However, from the available records the rust has not been recorded from Nigeria so far. The complete life history of this rust was earlier studied by Davis in 1930 using teliospores from Cyperus schweinitzii Torr. sown on Leptilon canadense (L.) Britt. The full description of the life cycle was published by Arthur (1934).

The rust was collected on the living leaves of Cyperus reduncus Hoechst and Boeck (Cyperaceae) from Samaru on October 10, 1982.

2. PUCCINIA ROMAGNOLIANA Maire and Saccardo

(Plate II ; Fig. 2 b.)

Occurrence :

The host Cyperus rotundus L. is a common weed in most of the cultivated fields in Nigeria. It is capable of perpetuating in the soil for several years due to the formation, in a chain, of a number of under ground rhizomes called 'nuts' from which it derives the common name of 'nut grass'. The rust appears on the host in its uredinial stage from July onwards. The telial stage quickly followed the uredinia and both are found mostly mixed. The rust continues to infect the host as long as it remains green.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : The rust spots prominent on the upper surface, irregular, surrounded by yellowish margin with brownish centre; when severely infected, many spots coalesce causing premature drying of the leaves; spots also formed on leaf sheath and

irregular, surrounded by yellowish margin with brownish centre; when severely infected many spots coalesce causing premature drying of the leaves; rust spots also formed on the leaf sheath and stem; uredinia hypophyllous, elongate, confluent, running along the veins, erumpent, epidermis rupture longitudinally forming a slit-like opening exposing the spore mass; sori pulverulent, dark brown in mass; spores broadly ellipsoid or obovoid, germ pores 2, equatorial, wall thin up to 2 μ, contents light brown, 22 x 19 μ (19 - 28 x 12 - 22).

Telia : Mostly hypophyllous, isolated or mixed with uredinia, subepidermal, covered by the epidermis, loculate, one or more locules in each sorus, surrounded by closely packed, vertically arranged paraphyses; teliospores 2 - celled, but 1 -celled or 3 - celled spores also seen, smooth walled, slightly constricted at the septum, apex rounded or obtuse, thickened up to 12 μ at the apex, contents brown, 19 x 47 μ (12 - 25 x 28 - 68); pedicel persistent, light coloured, up to 68 μ long and 4 - 5 μ broad; 1 - celled mesospores commonly mixed with the normal spores, apex rounded or flattened, 12.0 - 19.2 x 24.0 - 55.3 μ; paraphyses 14 - 19 μ broad and 24 - 36 μ long.

Identification :

Several rusts have been recorded on the host genus from different parts of the world and the details are given in Table 1. The rust under study closely resembles Puccinia romagnoliana in morphological characters and spore measurements. The comparative measurements of the rust under study and P. romagnoliana are given in Table 2.

Table 2. Comparative details of Puccinia romagnoliana and the rust under study.

Rust species	Uredinia			Telia		
	Measurements (in µ)	P	G P	Measurements (in µ)	P	MS
1. Puccinia romagnoliana	12 - 22 x 19 - 22	-	2 E	19 - 47 x 12 - 25	+	+
2. Rust under study	12.0 - 19.2 x 14.4 - 24.0	-	2 E	28.8 - 48.0 x 12.0 - 20.0	+	+

The first record of this rust was made by Maire and Saccardo (1903) based on the specimens collected on Cyperus difformis L. The same rust was further collected and recorded from Sudan (Tarr, 1955) and from India by Ramakrishnan and Sundaram (1956a). There is no previous record of this rust from Nigeria.

The full life cycle of this rust was established for the first time by Ramakrishnan and Sundaram (1956a) with Ipomea rumicifolia Choisy and I. pestigridis Linn. as its pycnial and aecial hosts.

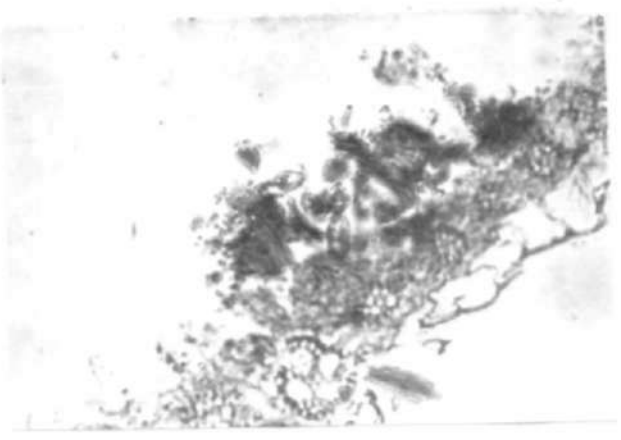
The rust specimens were collected on living leaves of Cyperus rotundus L. (Cyperaceae) from Zaria on October 12, 1982.



a. Infected leaves

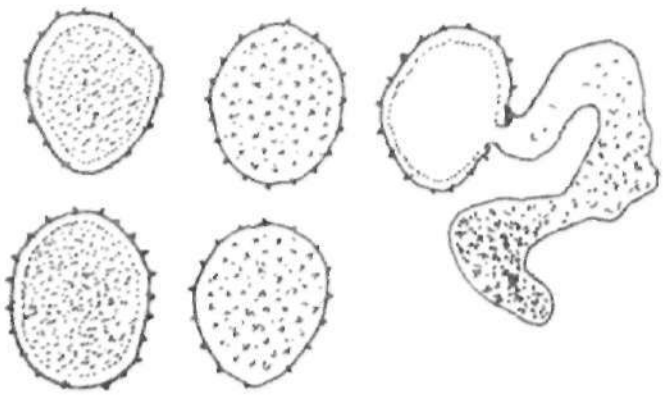


b. Urediniospores



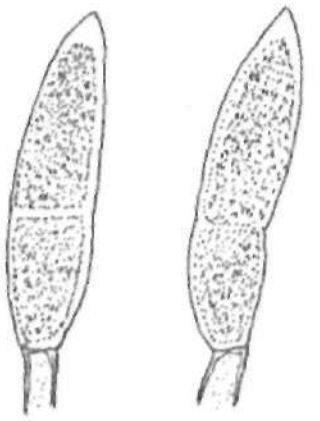
c. Teliospores (section)

PLATE II. Puccinia romagnoliana on Cyperus rotundus



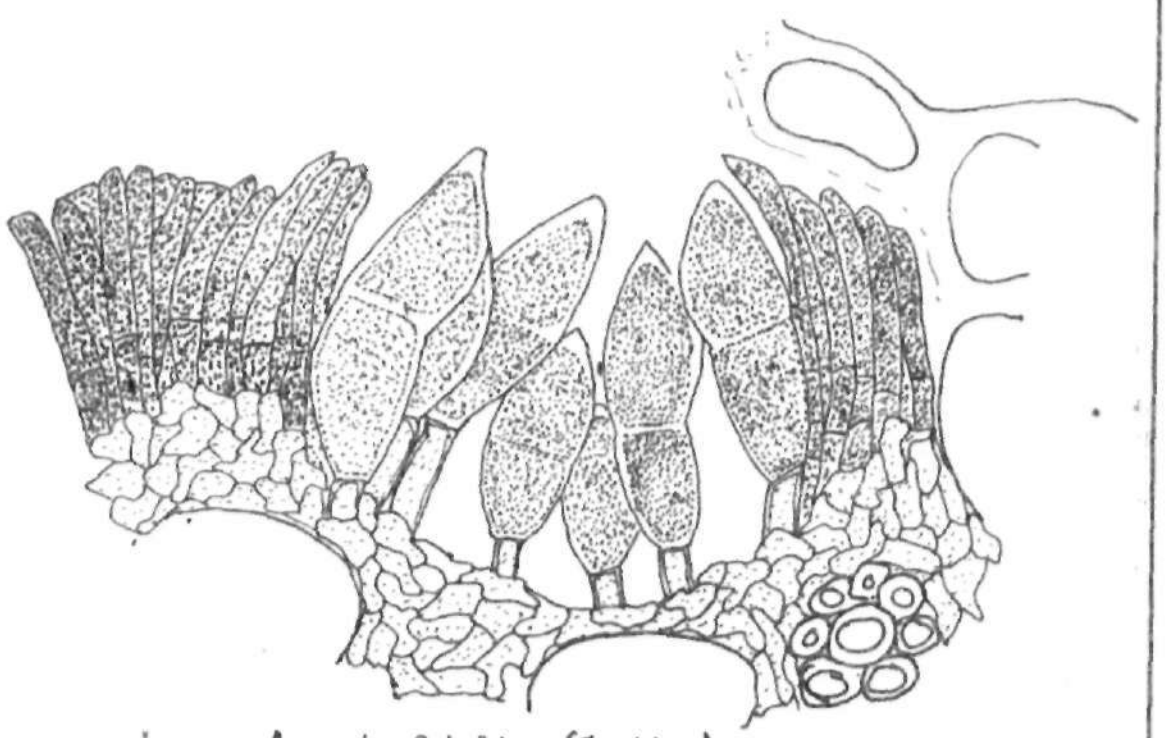
Urediniospores

Germinating urediniospore



Teliospores

50 μ



A part of telium (Section)

Fig. 2 B PUCCINIA ROMAGNOLIANA ON CYPERUS ROTUNDUS

3. MELAMPSORA EUPHORBIAE (Schubert) Castagne

(Plate III ; Fig. 3)

Occurrence :

The host Euphorbia heterophylla L. is a common weed in tropical countries. In Nigeria, this is found throughout the country growing during the rainy season. Only uredinia was collected. The rust appears on the host starting from the month of August and continues till the end of January. No fresh infection was observed beyond January even though the host remained green in certain localities. Eboh (1978) recorded this rust on Euphorbia heterophylla from Nsukka (Nigeria).

Description :

Pycnia, aecia and telia : Not observed during the studies.

Uredinia : Rust spots small, yellowish with irregular margin to start with but soon the size expands up to 5 mm, with age the centre of the spot becomes necrotic; uredinia mostly hypophyllous, in groups of 5 or 6 to start with, subsequently more uredinia formed in concentric circles around them, bright orange in colour, epidermis rupture exposing the powdery mass of spores; spores globose to obovoid, thick walled up to 4 µ, strongly echinulate, wall colourless, contents granular, bright orange, 24 - 28 x 15 - 18 µ; paraphysate, paraphyses numerous, marginal or mixed with the spores, clavate, thick walled, globose at the apex, hyaline to slightly yellowish.

Identification :

The rust under study closely resembles the uredinial stage of Melampsora euphorbiae recorded on the same host earlier. The first

record of this rust was made by Persoon in 1801 who named Uredo euphorbiae-helicoscopiae as well as U. euphorbiae-exigue. Subsequently several rusts were recorded on the host genus by various authors from different countries. However, Arthur, (1934) considers the following as synonyms :

Melampsora euphorbiae (Schub.) Cast.

M. euphorbiae-pepli W. Mull.

M. euphorbiae-exigue W. Mull

M. euphorbiae-cyparissiae W. Mull.

M. cyparissae M.W. Mull.

The rust was collected on living leaves of Euphorbia heterophylla L. (Euphorbiaceae) from Samaru on October 10, 1982.

Germination :

The urediniospores readily germinated when floated on drops of sterile distilled water within 24 hours. Normally a single germ tube was formed from each spore. The contents of the spore collect towards the growing point. The germ tubes are stout, thin walled with granular contents.

Comparative measurements of the spores from Eboh's description and the Zaria collection

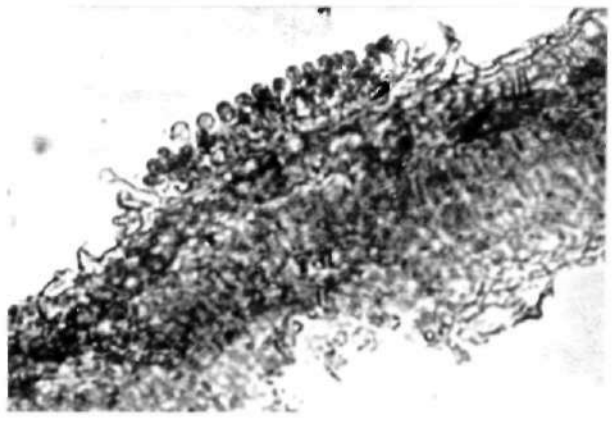
	Urediniospore size	Germpores	Paraphyses
Eboh's observation (Nsukka collection)	16 - 26 x 14 - 17 µ	Obscure	Present
Rust under study (Zaria collection)	24 - 28 x 15 - 18 µ	Obscure	Present



a. Leaves showing rust infection

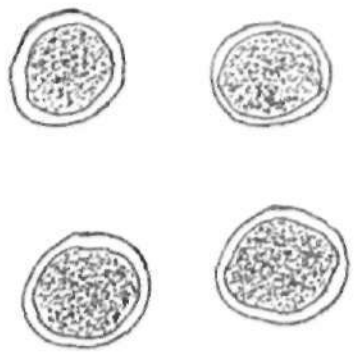


b. Urediniospores; paraphysis



c. Uredinium (section)

PLATE III. Melampsora euphorbiae on Euphorbia heterophylla

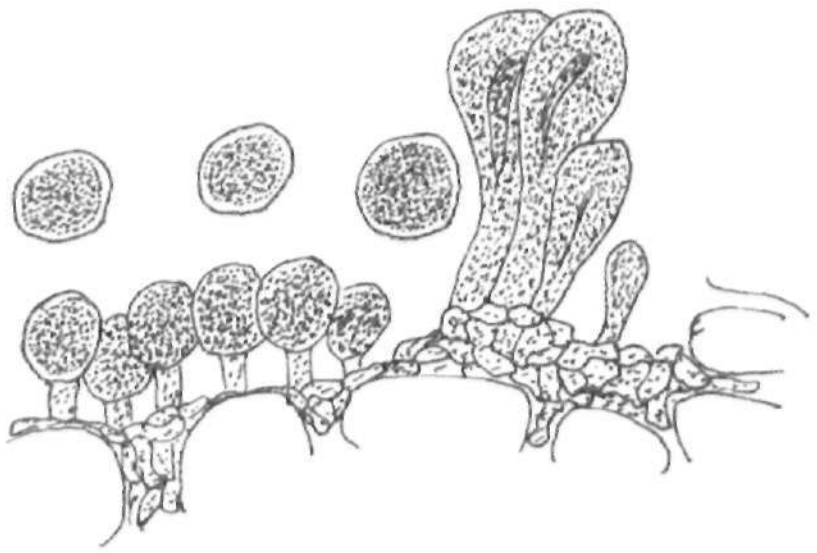


Urediniospores



Paraphyses

50 μ



Uredinium (Section)

Fig. 3 MELAMPSORA EUPHORBIAE ON EUPHORBIA HETEROPHYLLA

4. PUCCINIA ELLISIANA Thuemen

(Plate IV ; Fig. 4)

Occurrence:

The rust occurs on the host Andropogon gayanus Kunth. which is an annual weed found all over Nigeria. It mostly grows on field bunds and waste lands. New flush of the grass comes out soon after the onset of the rainy period and it survives till the end of November. The rust generally appears from the end of June in its uredinial form. The telia appear from September and continue till the host dries up.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Rust spots numerous, minute, inconspicuous, surrounded by green island; uredinia mostly hypophyllous, yellowish to cinnamon-brown, epidermis rupture early; spores obovate to globoid, wall uniformly thickened up to 4 µ, pale yellow, echinulate, spore contents bright yellow, germ pores 3 (4), subequatorial, 21.6 - 28.8 x 16.8 - 24.0 µ; apara-physate.

Telia : Sori hypophyllous, isolated, subepidermal in origin, erumpent, exposed, dark brown to blackish; spores 2 - celled, clavate or oblong -ellipsoid, wall uniformly thick at sides up to 4 µ, apex thickened up to 10 µ, smooth, chestnut-brown, contents lighter in colour, 19.0 - 26.0 x 33.6 - 52.0 µ, pedicel long, thin walled , up to 85 u, partially collapsing.

Identification :

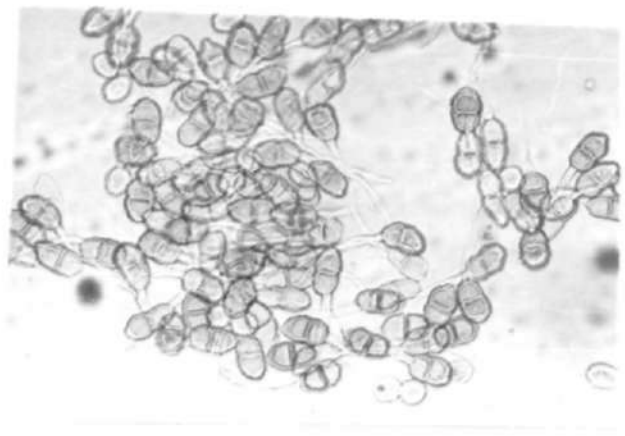
Several rusts have been recorded on the host genus from



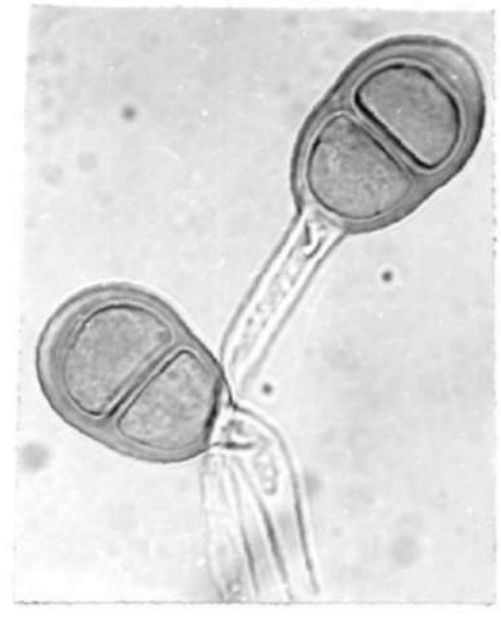
a. Infected leaves



b. Urediniospores



c. Teliospores in group



d. Teliospores

PLATE IV. Puccinia ellisiana on Andropogon gayanus

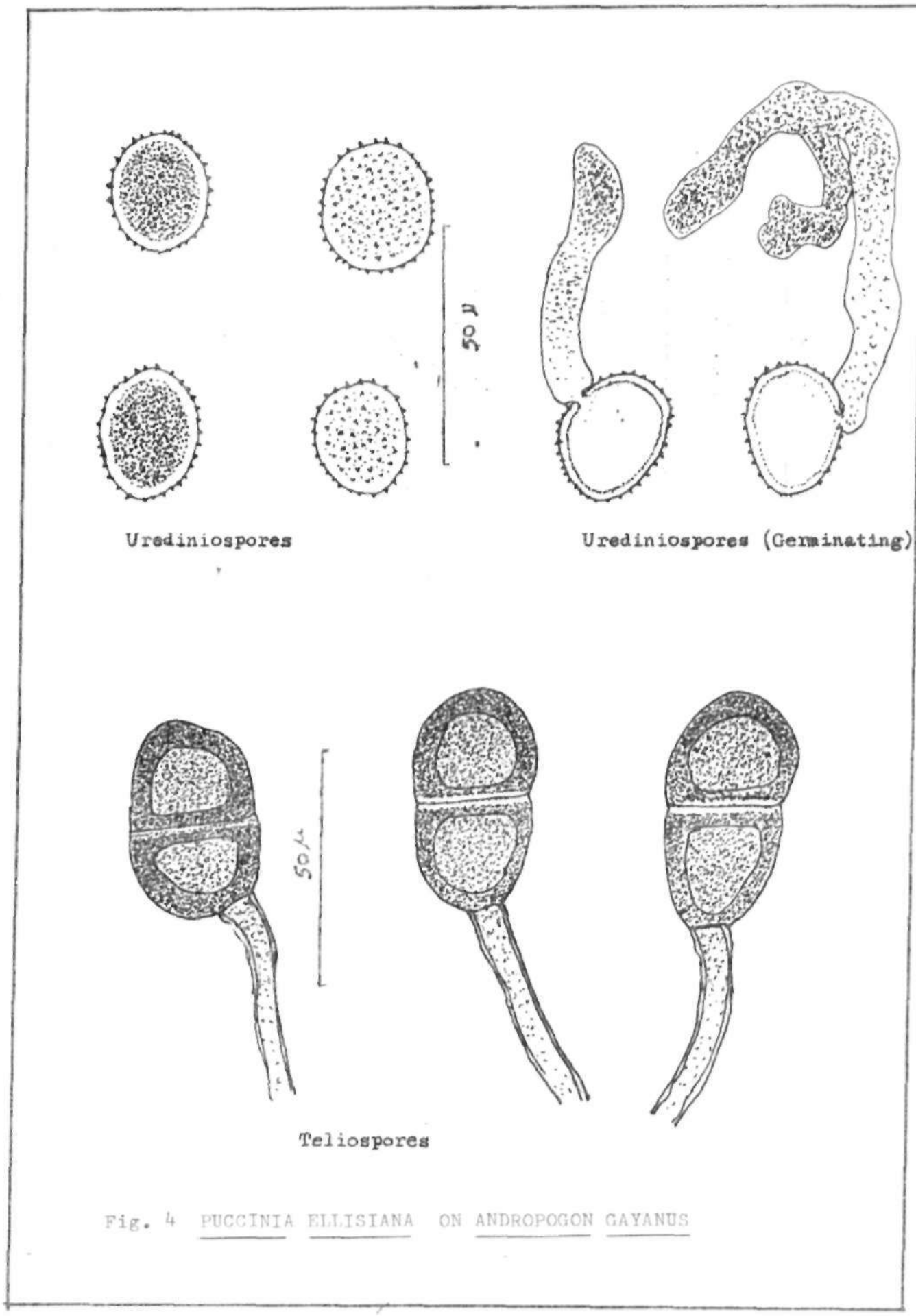


Fig. 4 PUCCINIA ELLISIANA ON ANDROPOGON GAYANUS

5. PUCCINIA CYNODONTIS Lacroix ex Desmazieres

(Plate V A & V B; Fig. 5 & 6)

Occurrence :

Cynodon dactylon (L.) Pers. and Leersia hexandra Sw. which are the hosts for this rust species are commonly found in most of the tropical countries growing in cultivated fields as well as in waste areas. They are perennial in nature and thrive well under adequate moisture levels. In Nigeria, these grasses are common in farm as well as in fallow lands. The rust was collected from these two hosts from Zaria and environs almost throughout the year. The uredinia were abundant in all the months but telia were more predominent in July and January.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Rust spots inconspicuous in early stage, linear, brownish when mature, confined between veins, epidermis rupture early; uredinia amphigenous but mostly hypophyllous, cinnamon-brown; spores globoid, wall thin, 2 - 3 µ thick, germ pores 2 (3), equatorial, surface verrucose, 20.0 - 29.0 x 18.0 - 24.0 µ.

Telia : Sori mostly hypophyllous, erumpent, exposed, dark brown, isolated or mixed with the uredinia; spores 2 - celled, ellipsoid, apex rounded or tapering, wall uniformly thick up to 2.5 µ, and at apex 6 - 12 µ, wall coloured brown, contents chestnut-brown, surface smooth, not constricted at the septum, 30.0 - 55.0 x 15.0 - 24.0 µ; pedicel light yellow to hyaline, thin walled, measuring up to 80 µ long.

Identification:

The rust under study closely agrees with the original descriptions of P. cynodontis published by de Lacroix on Cynodon dactylon from St. Romain-sur-Vienne, Aroundissement de Chatellerault in 1857. Subsequently, the same was recorded from many tropical countries (Cummins, 1971). The characters of the rust on these two hosts under study are compared with the original description in Table 4.

Table 4. Comparative characters of Puccinia cynodontis (Type) with the rusts under study

Rust species	Uredinia			Telia	
	Measurements (in µ)	P	G P	Measurements (in µ)	P
Puccinia cynodontis	20 - 26 x 19 - 23	--	2 E	30 - 55 x 16 - 22	-
Rusts under study					
on Cynodon dactylon	20 - 29 x 18 - 24	-	2(3)E	30 - 55 x 15 - 24	-
on Leersia hexandra	20 - 29 x 18 - 24	-	2(3)E	30 - 55 x 15 - 24	-

The life cycle of this rust was established by Transchel (1906) by sucessfully inoculating species of Plantago. Later, the pycnia and aecia of this rust were recorded from hosts belonging to the Euphorbiaceae, Plantaginaceae, Ranunculaceae, Saxifaraceae, Scrofulariaceae, Valeranaceae and Violaceae (Cummins, 1971).

The following rusts are considered to be synonyms by Cummins (1971):

1. Puccinia variana Diet.
2. Uredo elusnae-indicae Saw.

Eboh (1978) collected the rust from Nsukka on the host Cynodon dactylon. However, there is no record of the host Leersia hexandra being affected by the rust.

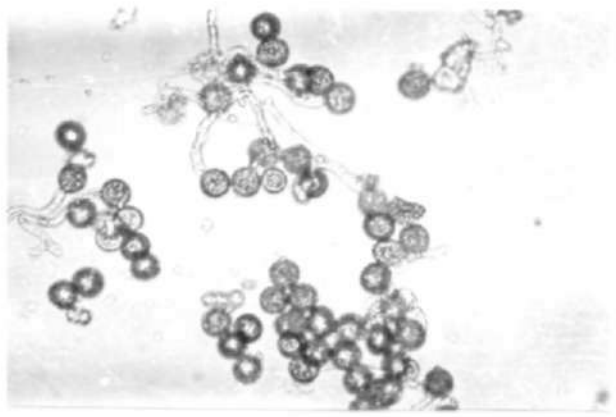
Germination :

The uredinio and telio spores were subjected to germination tests under the laboratory conditions. They were floated on drops of sterile distilled water and were kept under high moisture content for three days. The urediniospores started germination within three hours. The germ tubes came out of one of the germ pores and within six hours it reached to the leng of 2 - 3 times of the spore. The contents were colourless, granular and concentrated towards the growing point. Inspite of repeated attempts, teliospores did not show any sign of germination even after 72 hours.

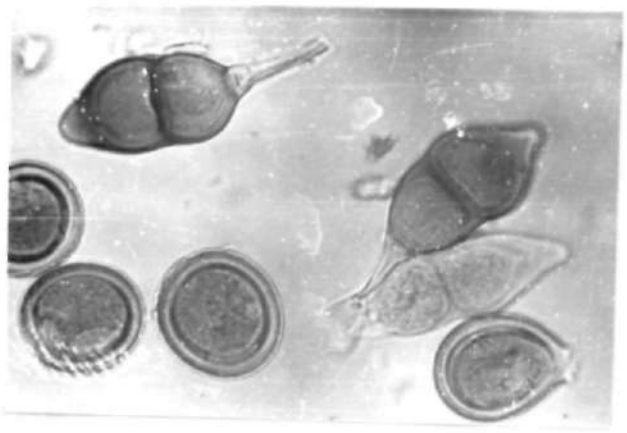
The rust specimens were collected on living leaves of Cynodon dactylon Lacroix ex Desmazieres and Leersia hexandra Sw. from Zaria on October 15, 1982. The specimens were deposited in Commonwealth Mycological Institute No. IMI 285924.



a. Infected plant



b. Urediniospores (germination)



c. Urediniospores and Teliospores

PLATE V. A. Puccinia cynodontis on cynodon dactylon

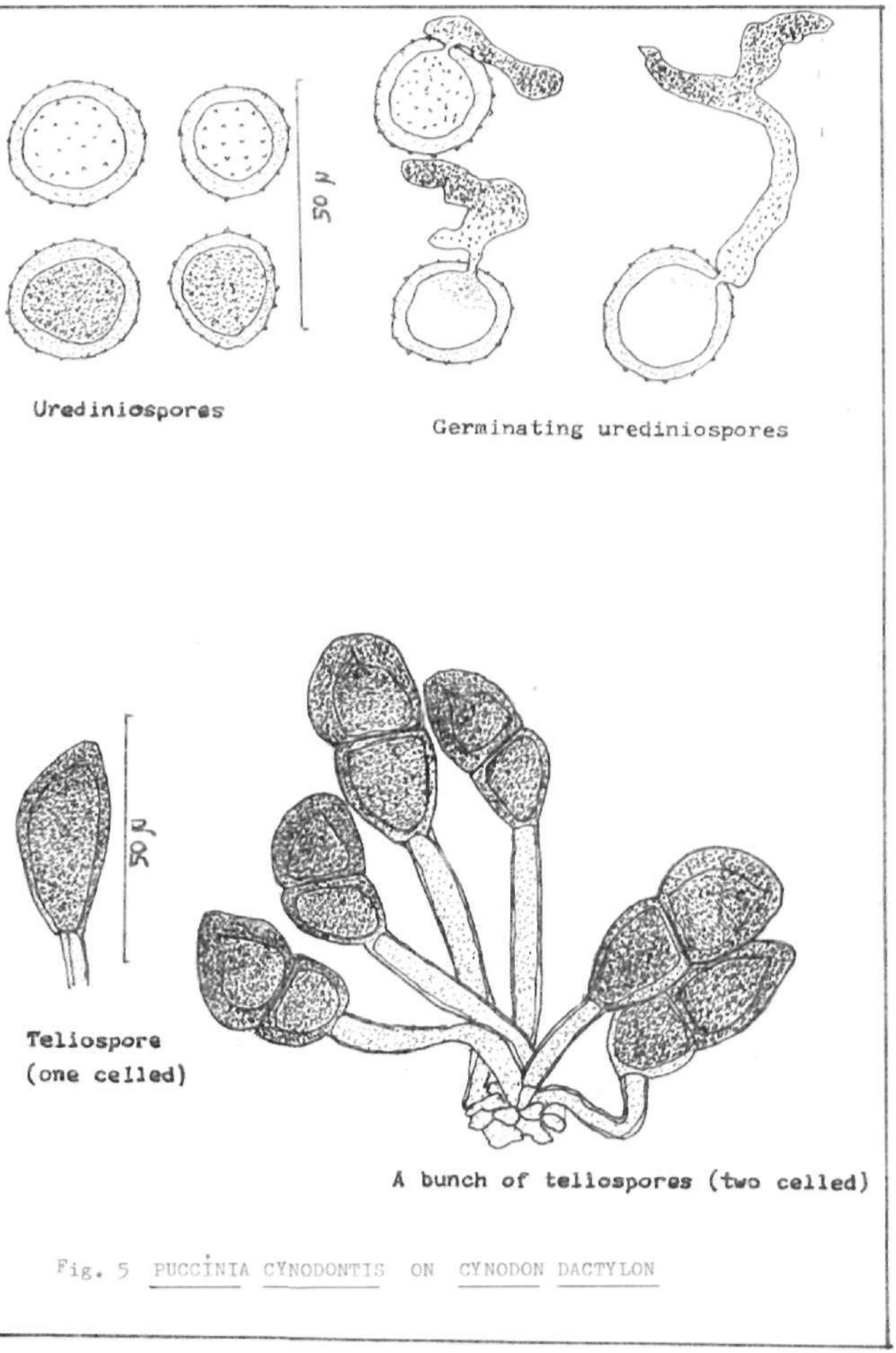
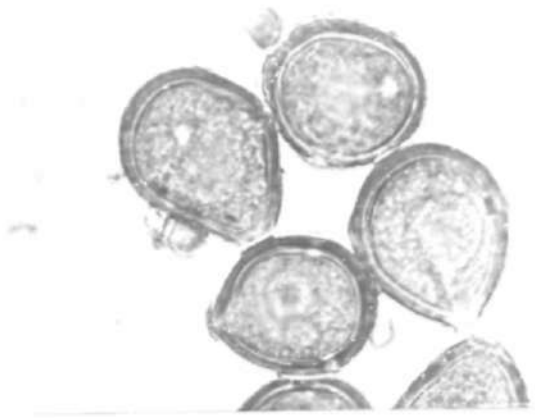


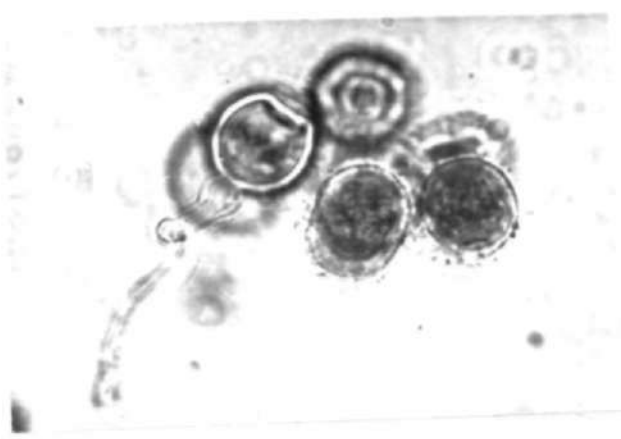
Fig. 5 PUCCINIA CYNODONTIS ON CYNODON DACTYLON



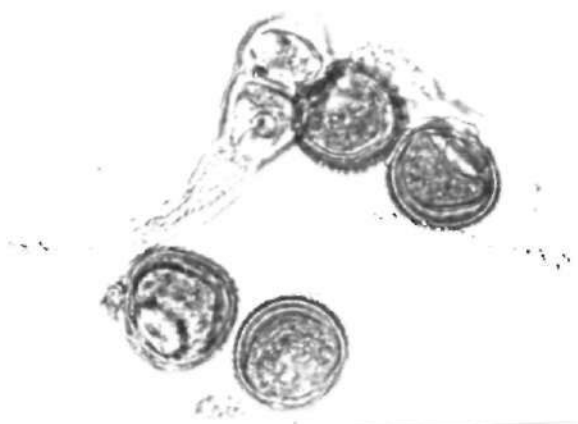
a. Infected leaves



b. Urediniospores



c. Urediospores (germniation)



d. Urediniospores and Teliospores

PLATE V. B. Puccina cynodontis on Leersia hexandra

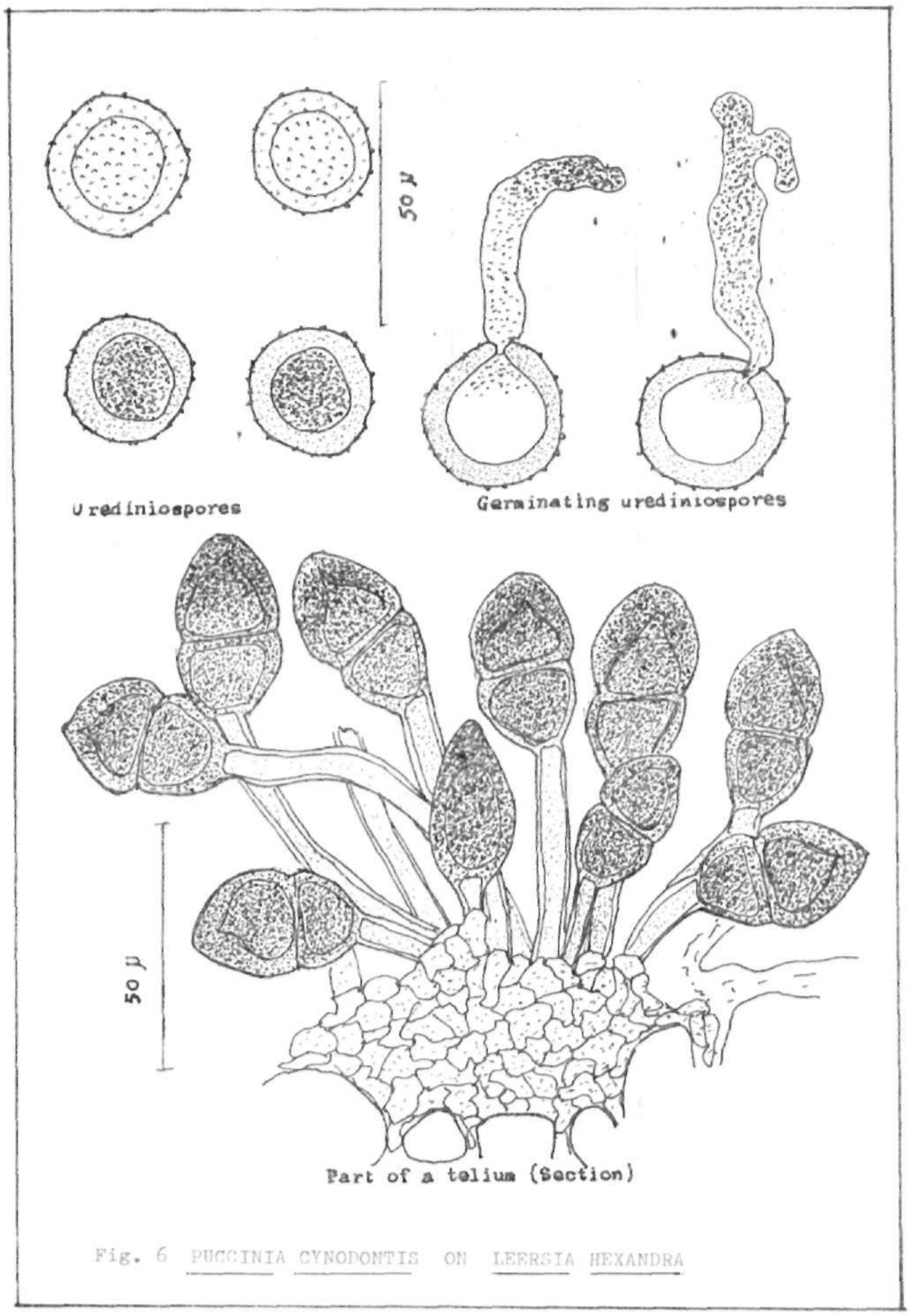


Fig. 6 PUCCINIA CYNODONTIS ON LEERSIA HEXANDRA

6. PUCCINIA OAHUENSIS Ellis and Everhart

(Plate VI ; Fig. 7)

The host Digitaria ciliaris (Ritz.) Koel. is a common grass weed found in many of the tropical areas. It is widespread in Nigeria. The grass remains green in and around Zaria from June to November. The rust was collected between July and November. The uredinia were more predominent during July and August and during subsequent months both uredinia and telia were found simultaneously.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Rust spots minute, oval to irregular, scattered, amphigenous, light yellow to start with, later becoming brown; uredinia amphigenous, scattered, minute, oval to elongate, epidermis long covered; spores spherical or obovate to oblong, wall thin, irregular, hyaline, verruculose to finely echinulate, germ pores 3 - 4 scattered, supra-equatorial, 28.8 x 21.6 µ (21.6 - 36.0 x 19.2 - 26.4), paraphysate; paraphyses clavate, smooth walled, measuring up to 36 µ long and 14.4 µ at apex, light brown, not collapsing.

Telia : sori amphigenous, isolated or intermixed with uredinia, long covered by epidermis; spores surrounded by clavate paraphyses, similar to those observed in uredinia; and tapering towards the pedicel, sometimes pedicel attached diorchoidly, wall uniformly thickened at sides up to 2.5 µ and at apex up to 7.5 µ, apex rounded or sometimes tapering, the septum prominent, slightly constricted, young teliospores

with granular contents, yellowish brown initially, at maturity the contents become opaque and the colour changes to golden to chestnut brown. 40 x 19 u (36 - 48 x 16.8 - 21.6), pedicel thin walled, colourless, not collapsing, short.

Identification :

Several rusts have been recorded on the host genus from various countries in the past, the details of which are given in Table 5. The first record of Puccinia oahuensis was made by Ellis and Everhart (1895) based on the specimens (Heller No. 1976) on an unidentified grass (Digitaria pruriens ?) from Oahu, Hawaii.

Table 5. Comparative morphological characters of rusts recorded on the genus Digitaria and the rust under study

Rust species	Uredinia			Telia	
	Measurements (in μ)	P	GP	Measurements (in μ)	P
P. digitariae-velantinae V. Bour.	28 - 35 x 18 - 28	+	5 - 8 S	36 - 52 x 17 - 24	-
P. esclavensis Diet. & Holw. var. panicophila (Speg.) R.& C.	26 - 39 x 19 - 23	+	4 - 6 E/S	28 - 41 x 22 - 31	-
P. oahuensis E.&E.	23 - 40 x 18 - 28	+	4 - 6 E	27 - 52 x 12 - 25	+
P. pseudoatra Cum.	23 - 28 x 21 - 26	-	6 (5-8) S	28 - 39 x 20 - 26	-
P. imposita var. imposita (Arth.)R&C	29 - 37 x 20 - 37	+	4 (3-5) E	29 - 50 x 20 - 29	-
Rust under study	21.6 - 36.0 x 19.0 - 26.4	+	3 - 4 E/S	36 - 48 x 16.8 - 21.6	+

The rust collected on Digitaria ciliaris closely resembles Puccina oahuensis recorded on Digitaria pruriens ? in spore measurements, presence of paraphyses in uredinia and telia, spore shape, colour and wall markings. The only variation observed was in the number of germ pores which are 3 - 4 in the rust under study but 4 - 5 in P. oahuensis. However, considering the similarities in most of the characters of the rust under study with the original descriptions of P. oahuenssis, it is identified as such. This rust is recorded for the first time for Nigeria.

Cummins (1971) considers the following rusts as synonyms to Puccinia oahuensis :

Uredo digitariae Thuem.

Uredo digitariae-ciliaris Mayer

Uredo duplicata Rangel

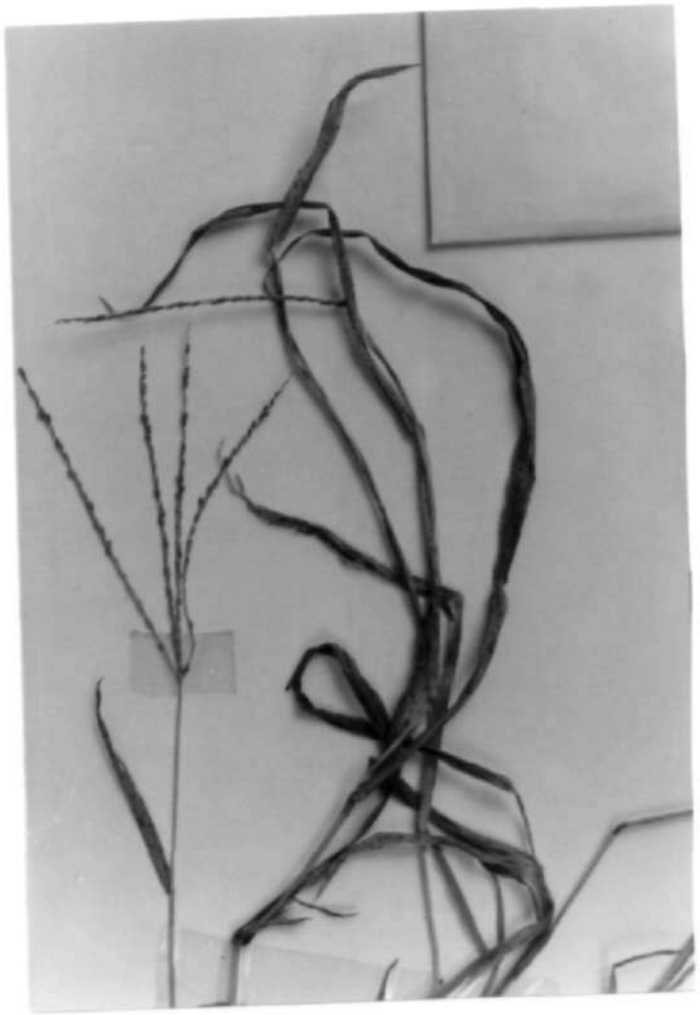
Puccinia digitariae Pole Evans

Uredo syntherèssimae Spegazzini

Germination :

Urediniospores readily germinated when kept afloat on distilled water and within 6 hours gave out long straight or curved germ tube, the content of which were granular, hyaline and concentrate towards the growing tip. Inspite of repeated tests, the teliospores did not germinate.

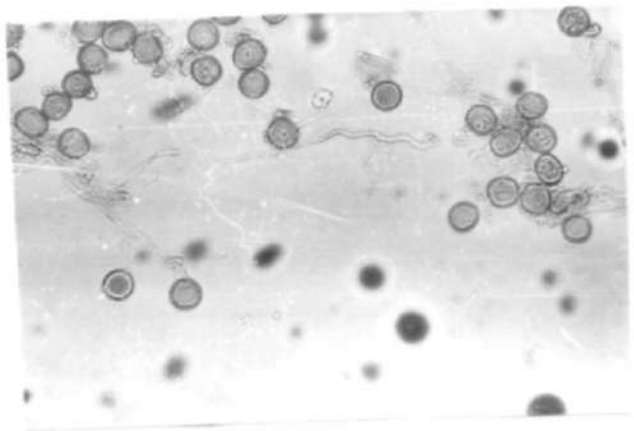
The specimens were collected on living leaves of Digitaria ciliaris (Retz.) Koel. (Gramineae), from Zaria, on October 16, 1982.



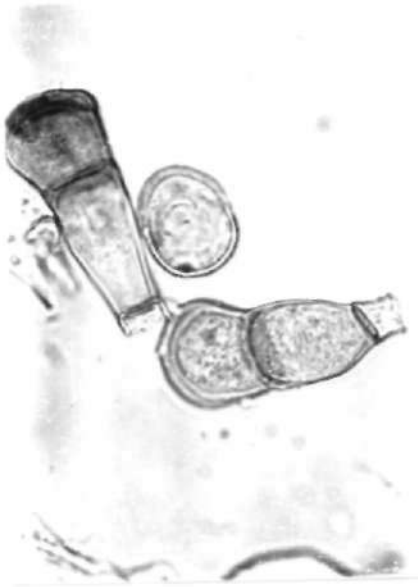
a. Infected leaves



b. Urediniospore



c. Urediospores (germination)



d. Teliospores

PLATE VI. Puccinia oahuensis on Digitaria ciliaris

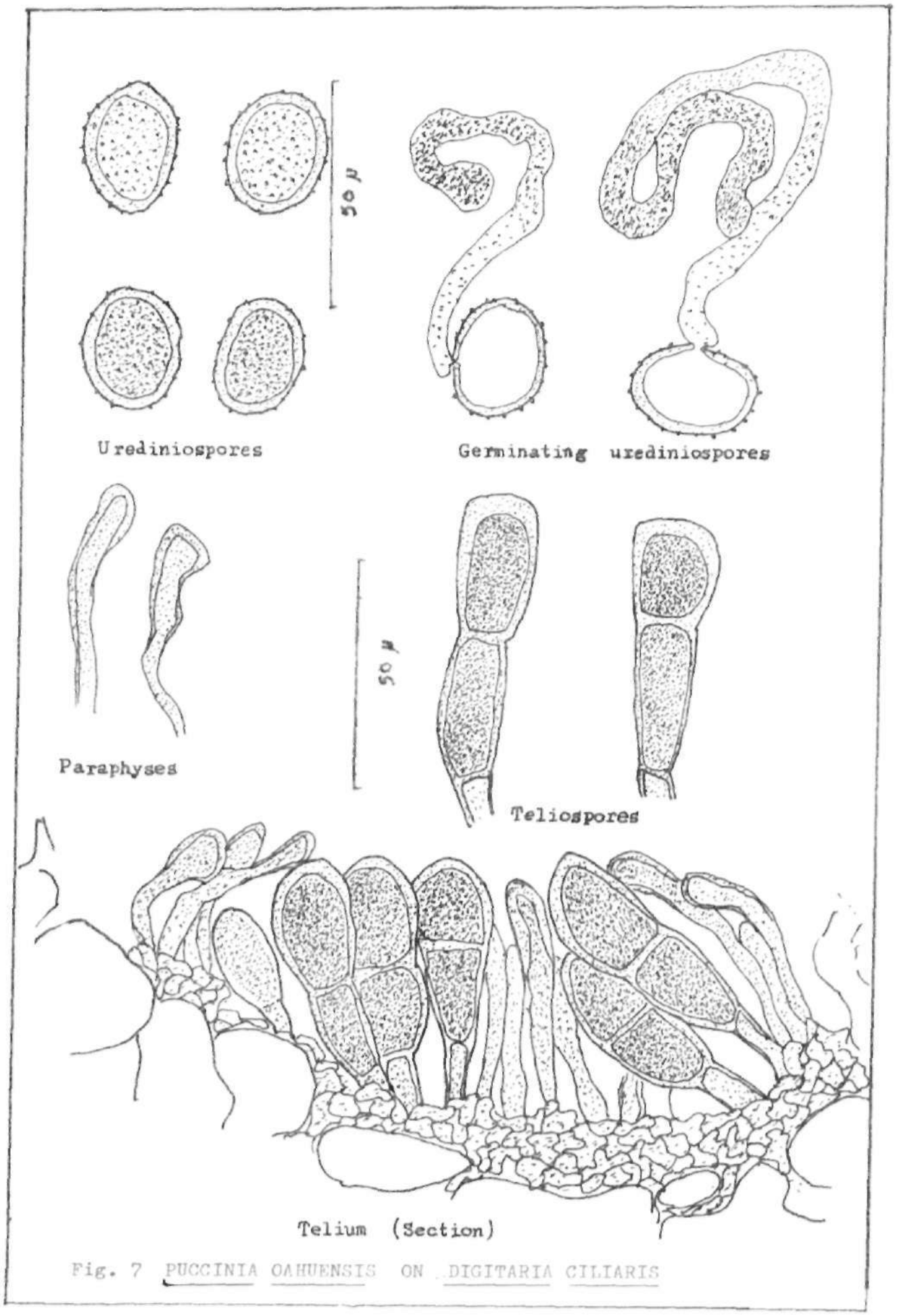


Fig. 7 PUCCINIA OAHUENSIS ON DIGITARIA CILIARIS

7. PUCCINIA ERITRAEENSIS Pazschke

(Plate VII ; Fig. 8)

Occurrence :

The host Hyparrhenia bagirmica (Stapf) Stapf is a common weed growing on field bunds throughout Nigeria. It remained green during June to November. The rust appears on the host in its uredinial stage from July onwards. The telia appeared from September onwards. and continued till the host dried up.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Rust spots numerous, prominent, dark brown, amphigenous, scattered; uredinia mostly hypophyllous, isolated, minute, epidermis ruptures early exposing the spore mass; spores obovate to globoid, wall uniformly thickened up to 2 µ, cinnamon-brown or slightly darker, strongly echinulate, germ pores 6 - 9, scattered, contents dark brown, 22 -29 x 17 - 26 µ; paraphysate, paraphyses yellowish, incurved, wall thickened up to 16 µ at the apex, thinner towards base.

Telia ; Mostly hypophyllous, prominent, dark, isolated or formed with uredinia, erumpent, epidermis rupture early; teliospores 2 - celled, ovate, surface smooth, wall uniformly thickened up to 3 µ at sides and 9 µ at the apex, rounded at the apex or slightly protruding, the colour of the contents deepens towards the upper cell; pedicel persistent, long, thin walled, colourless or sometimes light yellow, 88 µ long, collapsing; 1 - celled mesospores present, 22 - 29 x 19 - 26 µ.

I entification :

Several rusts have been recorded on the host genus Andropogon the details of which are given in Table 7. The comparative spore measurements and other details of the rust collected from Zaria are given along with the original descriptions of P. eritraeensis in Table 6.

Table 6. Characters of Puccinia eritraeensis compared with Zaria collection

Rust species	Uredinia			Telia	
	Measurements (in µ)	P	GP	Measurements (in µ)	P
P. eritraeensis Pas.	24 - 35 x 16 - 27	+	6 - 9 S	30 - 46 x 19 - 29	-
Rust under study	22 - 29 x 19 - 26	+	6 - 9 S	38 - 45 x 24 - 26	

Pazschke (1893) described the rust based on the type specimen collected by Schweinforth, on Andropogon sp., from Haschello Kobok, Eritrae (E). The rust has a wide host range and has been recorded, besides the genus Andropogon, on Cappillipedium, Cymbopogon, Hyparrhenia and Trechepogon from Africa to Australia and in Honduras (Cummins,1971). There is no previous record of this rust from Nigeria.

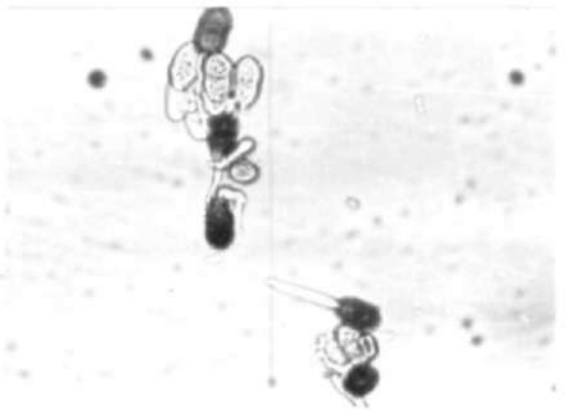
The specimens were collected from Zaria on living leaves of Hyparrhenia bagirmica (Stapf) Stapf (Gramineae) on October 15, 1982.



a. Infected leaves

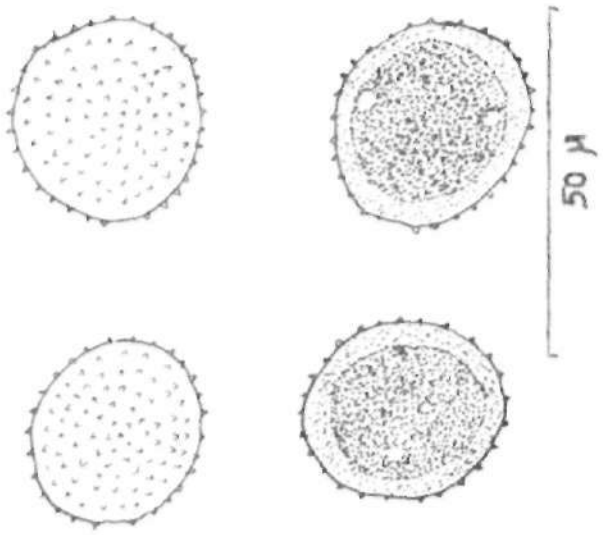


b. Urediniospore

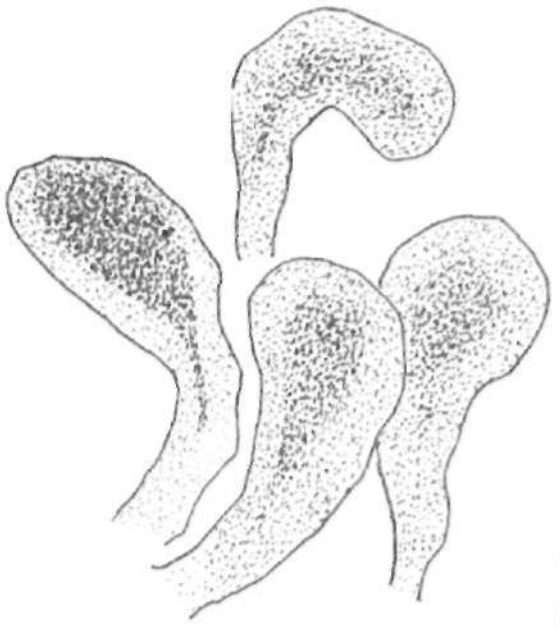


c. Teliospores (young hyaline and matured deep coloured)

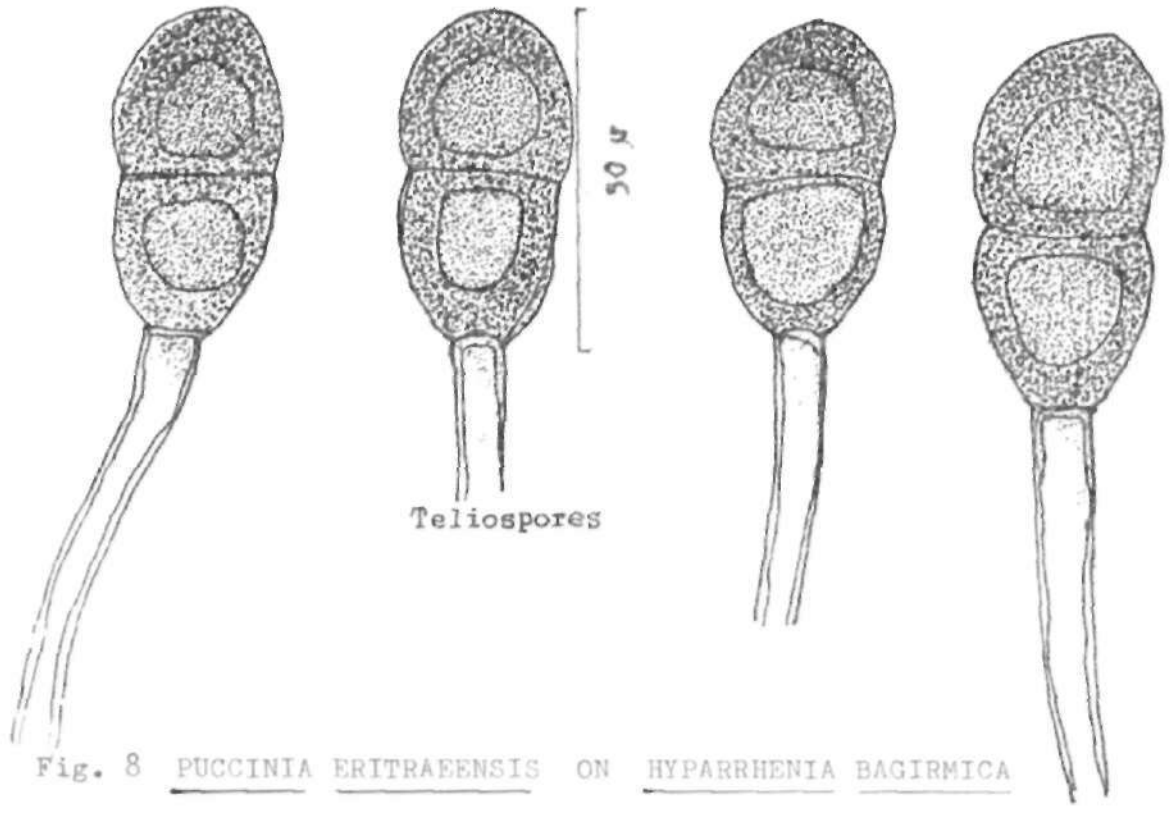
PLATE VII. Puccinia eritraeensis on Hyparrhenia bagirmica



Urediniospores



Paraphyses



Teliospores

Fig. 8 PUCCINIA ERITRAEENSIS ON HYPARRHENIA BAGIRMICA

8. PUCCINIA VERSICOLOR Dietel and Holway

(Plate VIII A & B ; Fig. 9 & 10)

Occurrence :

The hosts Hparrhenia rufa (Nees) Stapf and Rottboelia exaltata L. f. are common obnoxious weeds in cultivated fields. They are widely distributed in many of the tropical countries. In Nigeria, they are considered to be economically important weeds. In and around Zaria, these grasses grow luxuriantly during the rainy season. They dry up during the dry periodfrom November to May. The rust occurs on these hosts from July through January. The uredinia are the first to appear followed by the telia which normally appear from August onwards.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Rust spots amphigenous but mostly hypophyllous, isolated or in groups of 4 - 5, bright yellow; spores come out through the slit-like opening, ellipsoid to oboveid wall 3 - 6 µ at sides and up to 8 µ at the apex, inner surface irregular and giving a stellate appearance to the lumen, colourless, germ pores obscure, 20-24 x 17 - 24 µ; aparaphysate.

Telia : Isolated or mixed with uredinia, epidermis rupture early exposing dark brown, pulverulent, erumpent spore mass; teliospores 2 - celled, chestnut-brown, wall uniformly thick up to 2.5 µ at sides and up to 8 u at apex, mostly broadly ellipsoid or oblong, 27 - 36 x 17 - 25 µ; pedicel very long up to 100 µ and 5 µ broad, colourless and thin walled.

Identification :

As many as 9 rust species are recorded on the host genera so far from many parts of the world (Cummins, 1971). Their comparative morphology and spore measurements are given in Table 7.

Table 7. Details of rusts recorded on Hyparrhenia and Rottboelia species and the rusts under study

Rust species	Uredinia			Telia	
	Measurements (in µ)	P	GP	Measurements (in µ)	P
On Hyparrhenia species					
Puccinia levis (Sacc. & Bizz.)Magn.	25 - 31 x 23 - 27	-	2 E	31 - 43 x 26 - 33	-
P. hyparrheniae Cumm.	27 - 33 x 24 - 27 (apex 19 u)	-	3-4 E	38 - 40 x 25 - 28	-
P. versicolor Diet. & Holw.	25 - 33 x 21 - 28 (inner surface stellar)	-	8-11 S	40 - 56 x 22 - 27	-
P. andropogonicola Harriot & Pat.	29 - 35 x 2? - 26	+	4 - 5 E	40 - 56 x 22 -,27	-
P. eritraeensis Pazz.	24 - 35 x 16 - 27	+	6 - 10 E	30 - 46 x 19 - 29	-
P. andropogonis Fuckel	29 - 35 x 24 - 28	+	6 - 10 S	32 - 38 x 22 - 28	-
P. hyparrhenicola Joert. & Cumm.	20 - 24 x 17 - 24	+	6 - 8 S	32 - 38 x 22 - 28	-
Zaria collection on Hyparrhenia rufa	20 - 24 x 17 - 24 (inner surface stellar)	+	8 - 10 S	27 - 36 x 17 - 25	-

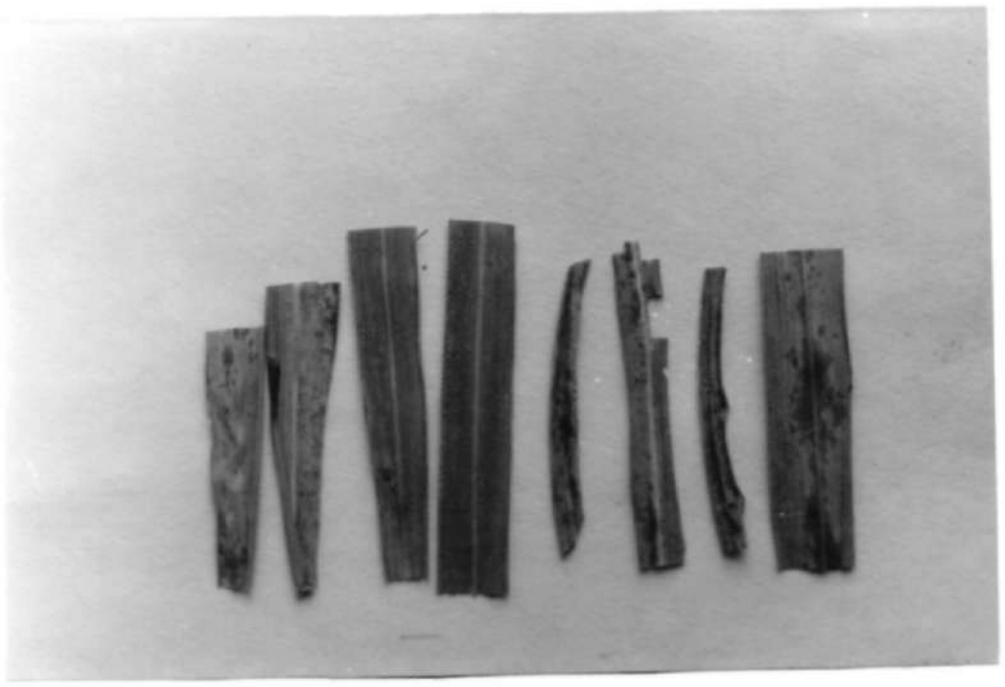
Table 7 continued.

1	2	3	4	5	6
On Rottboelia species					
Puccinia cacao McAlp.	29 - 42 x 23 - 29	+	3 (4) E	30 - 39 x 18 - 22	-
P. microspora Diet.	25 - 38 x 14 - 23	+	4 (5) E	25 - 38 x 14 - 23	-
Zaria collection on Rottboelia exaltata	20 - 26 x 17 - 24	+	8 - 10 O	27 - 38 x 19 - 25	-
(inner surface stellar)					

The morphological characters and the spore measurements of the rust under study collected on the two hosts very closely resemble those of P. versicolor especially with the stellar inner surface of the urediniospores which is very characteristic of the rust, and therefore, recorded as such. The two hosts grow side by side in many locations in Nigeria and also get infected by the same rust. The host Rottboelia exaltata is a new record for this rust.

The first record of this rust was made by Dietel and Holway (1897) based on the specimens collected on Heteropogon melanocarps (Ell.) Benth. from Guadalajare, Mexico. This rust has wider host range and circumglobal distribution. The genera of hosts recorded for this rust include Andropogon, Bothriochloa, Capillipedium, Cymbopogon, Heteropogon, Hyparrhenia, Ischaemum, Monocymbium, Themeda and Trachypogon.

Inoculations proving the aecial stage was made on Canthium (Plectronia) parviflorum Linn. by Thirumalachar and Narasimhan (1949) and on Lantana indica Linn. by Patil and Thirumalachar (1964). None of the above hosts were reported in the past to be affected by the rust in Nigeria.



a. Infected leaves



b. Urediniospores (germination)



PLATE VIII. A. Puccinia versicolor on Hyparrhenia rufa

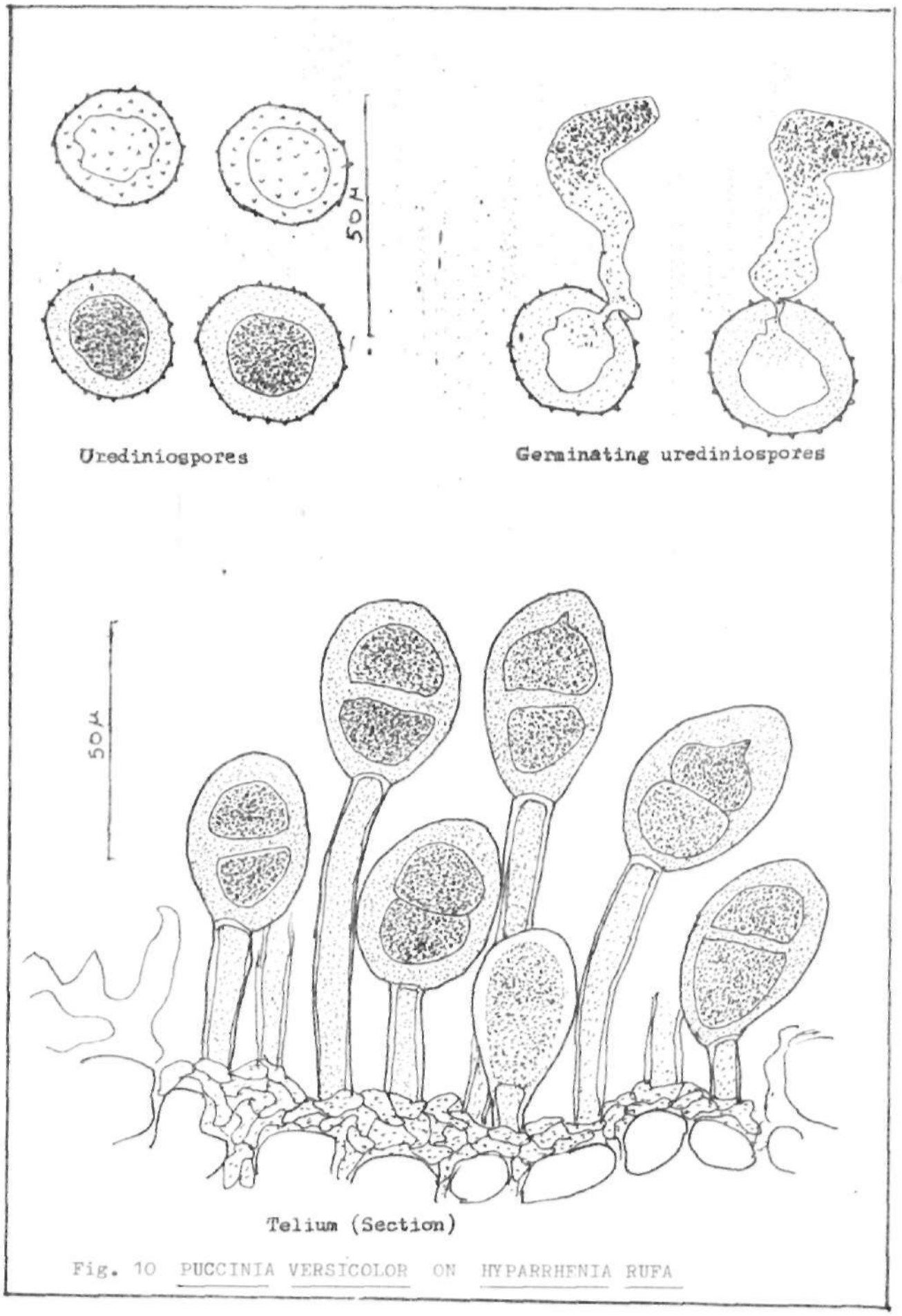
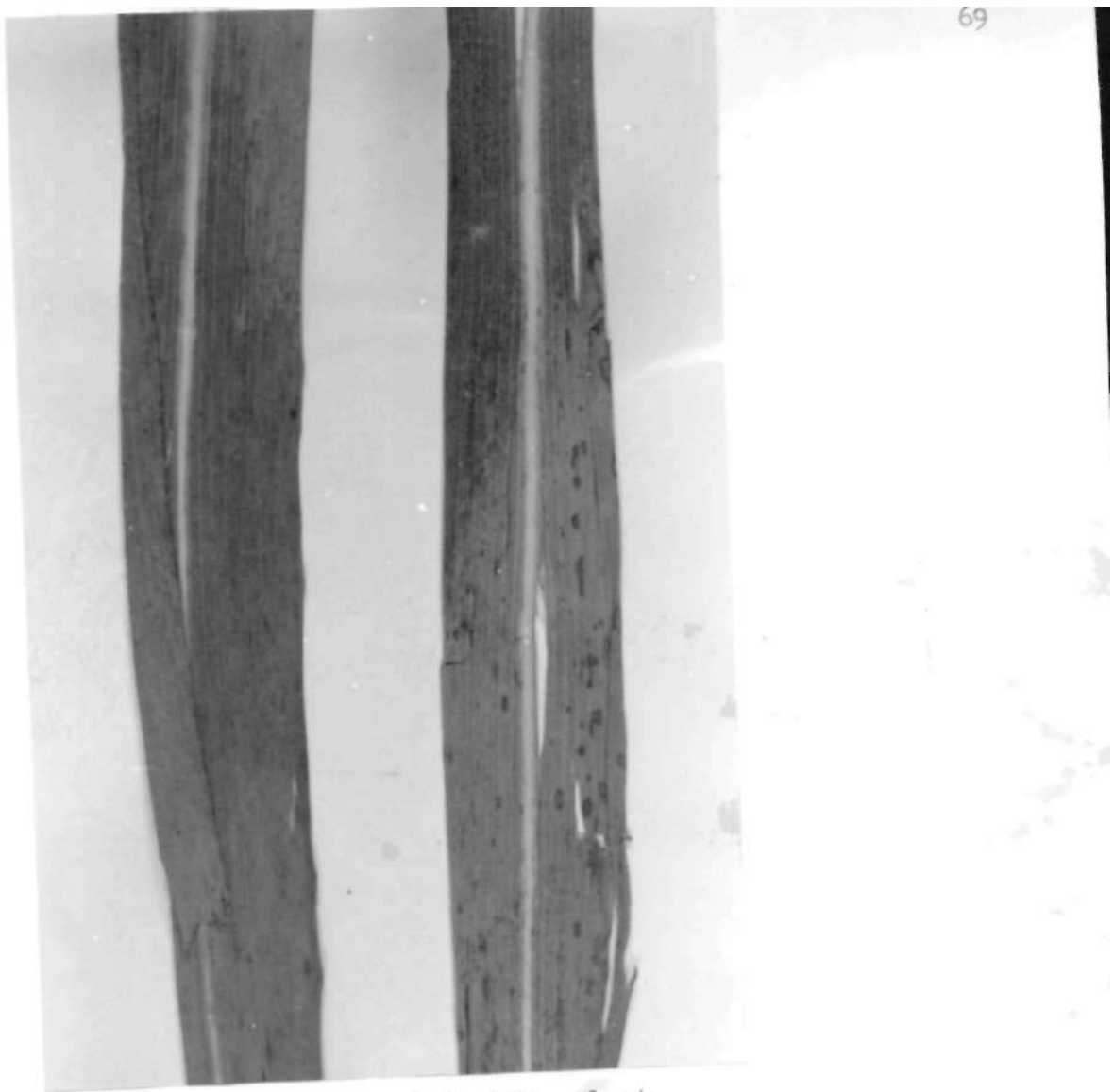
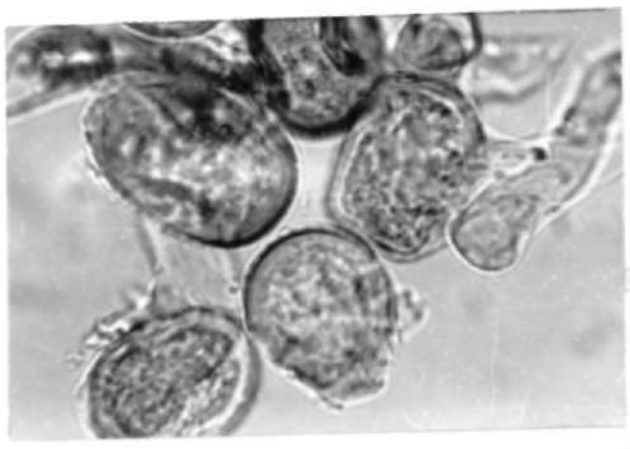


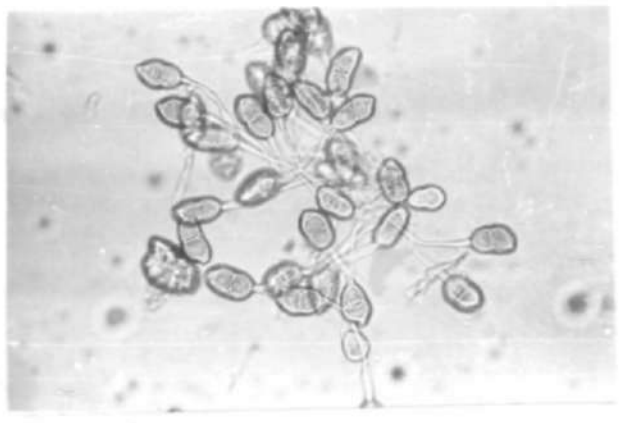
Fig. 10 PUCCINIA VERSICOLOR ON HYPARRHENIA RUFA



a. Infected plant



b. Urediniospores



c. Teliospores

PLATE VIII B. Puccinia versicolor on Rottboelia exaltata

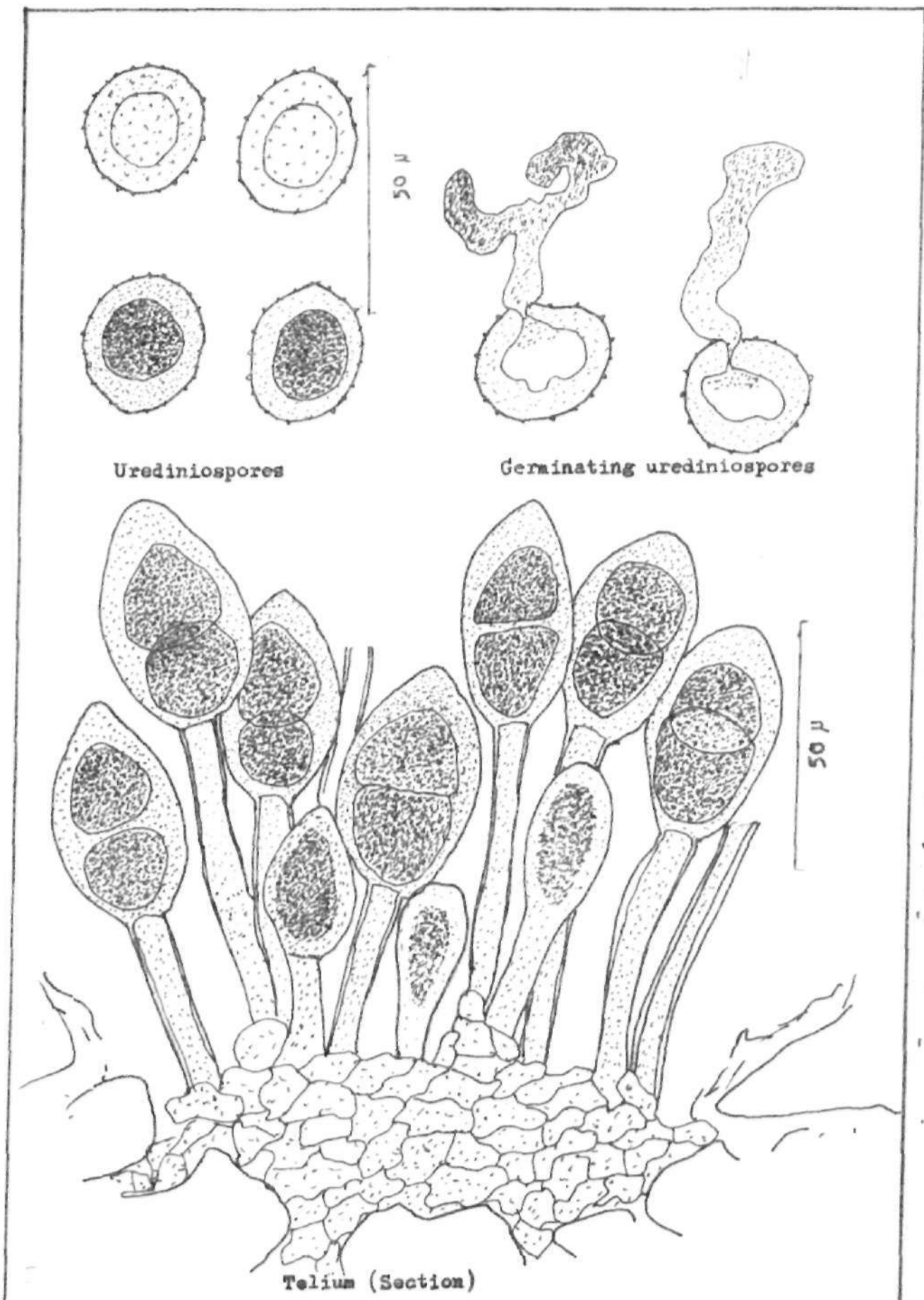


Fig. 9 PUCCINIA VERSICOLOR ON ROTTBOELIA EXALTATA

The specimens were collected on living leaves of Hyparrhenia rufa (Nees) Stapf and Rottboelia exaltata L.f. (Gramineae) from Zaria on October 10, 1982.

9. PUCCINIA SPECIES NOVA

(Plate IX ; Fig. 11`a.)

Occurrence :

The rust was collected on Hyparrhenia rufa (Nees) Stapf from Zaria as well as from Mokwa. The uredial stage was prominently seen from September onwards and the telia were collected during October to January.

Description :

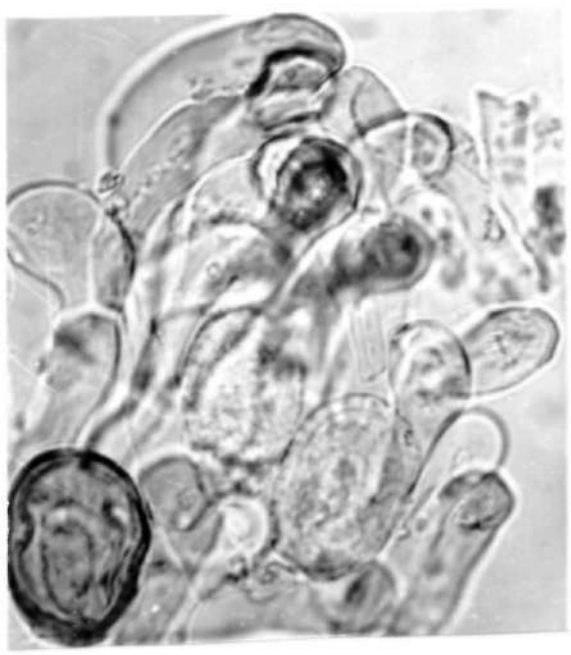
Pycnia and aecia : Not observed during the studies.

Uredinia : Rust spots amphigenous, chocolate brown, oval to irregular, aggregate forming large patches; uredinia mostly hypophyllous, linear, confined between the veins, light brown, epidermis rupture early exposing the urediniospores; urediniospores obovate to spherical, thin walled, light yellow, surface very finely echinulate, germ pores 3 - 6, obscure, mostly equatorial, contents yellowish brown to dark brown, 16.8 - 26.4 x 24.0 - 31.2 µ; paraphysate, paraphyses clavate, incurved, wall thick, light brown.

Telia : Mixed with uredinia, dark brown, sub-epidermal, epidermis rupture early exposing dark brown mass of spores; teliospores 2 - celled, cylindro-clavate, bottom cell narrowing



a. Infected plant



b. Urediniospores and paraphyses



c. Teliospore and paraphysis

PLATE IX. Puccinia species nov. on Hyparrhenia rufa

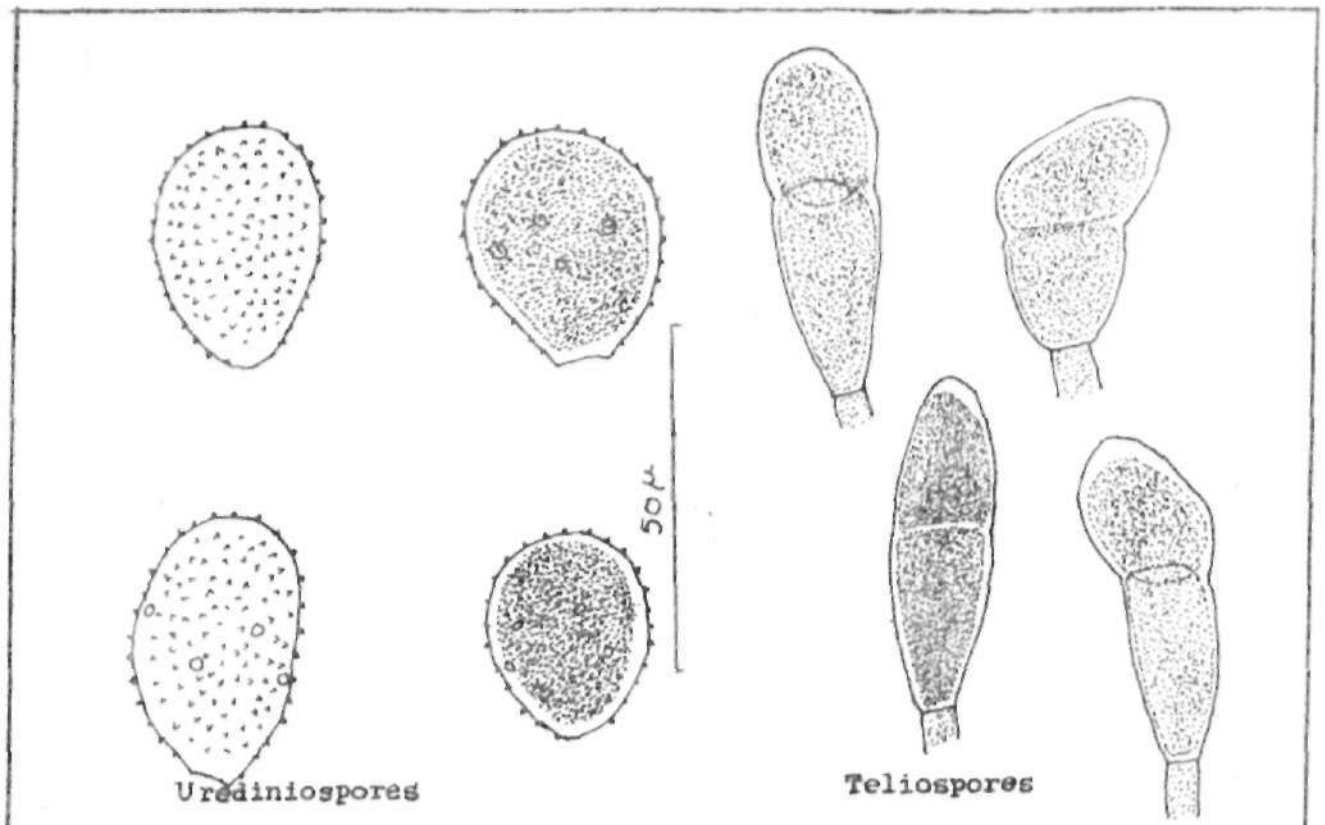


Fig. 11 A PUCCINIA SPECIES NOVA ON HYPARRHENIA RUFA

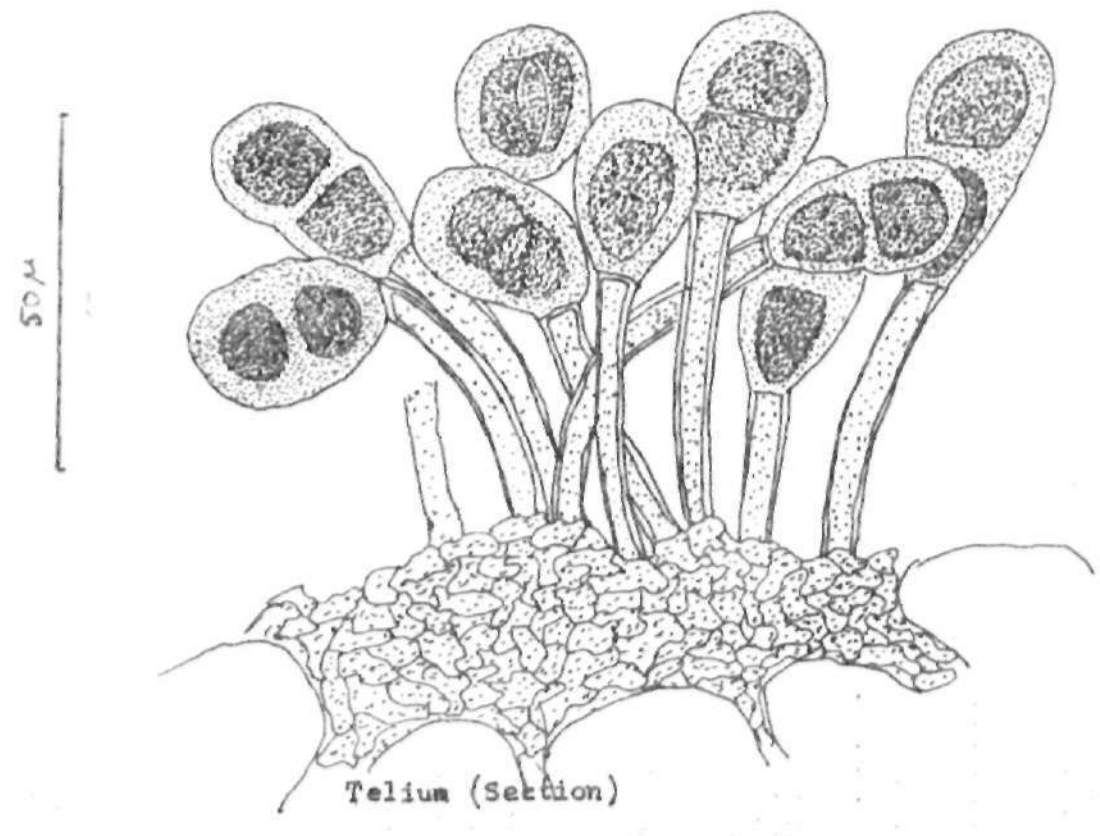


Fig. 11 B PUCCINIA LATERITA ON BORRERIA RADIATA

towards the pedicel, prominently constricted at the septum, thin walled at sides up to 1.5 µ, apex thickened up to 3 µ, 38.4 - 52.8 x 12.0 - 16.8 u, surface smooth, pedicel persistent, short, thin walled, collapsing: paraphyses clavate to obclavate, thin walled, 38.4 - 72.9 µ long and 9.6 - 14.4 µ broad.

Identification :

The details of the various rusts recorded on this host genus are given in Table 7. On examination and comparision of various characters of all the rusts recorded on this host genus so far, it was seen that the rust under study differs from the rest in its telial wall being uniformly thinner than the rest, light coloured contents and short pedicel. The urediniospores of the rust under study also vary in size, the number of germ pores and their mode of distribution. It is therefore considered to be a new species.

The specimens were collected on living leaves of Hyparrhenia rufa (Nees) Stapf (Gramineae) from Zaria on October 12, 1982.

10. UREDO SPECIES NOVA

(Plate X a ; Fig. 12 c.)

Occurrence :

The host Imperata cylindrica (L.) Beauv. is an obnoxious weed commonly grown in cultivated fields and bunds. This is perennial in nature. The rust appeared only in its uredinial stage from July through November in and around Zaria. There was no fresh infection beyond November even though the grass remained green. Eboh and Obike

Description :

Pycnia, aecia and telia : Not observed during the studies.

Uredinia : Rust spots linear, yellowish brown, scattered, prominent, epiphyllous; sori hypophyllous, brown to golden yellow, epidermis long covered except a slit-like opening in the middle; spores spherical to obovate, uniformly thickened wall up to 2.5 u, light brown, finely echinulate, contents yellow to orange, germ pores 5 - 6, scattered, 24 - 36 x 24 - 31 u; aparaphysate.

Identification :

Several rusts have been recorded on the host genus, the details of which are given in Table 8.

Table 8. Details of the rusts recorded on Imperata species and the rust under study

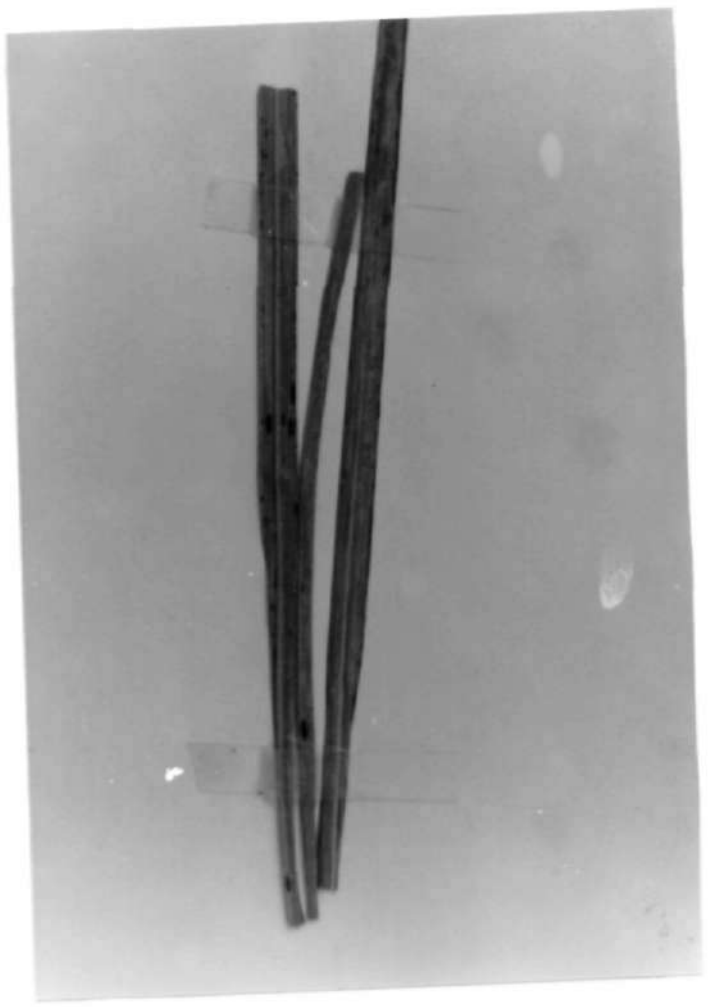
Rust species	Uredinia			Telia		
	Measurements (in µ)	P	GP	Measurements (in µ)	P	Apex (µ)
Puccinia imperatae Poirault	23 - 30 x 18 - 22	-	4 E	35 - 50 x 19 - 26	-	5 - 8
P.rufipus Diet.	27 - 33 x 18 - 25	+	4 E	30 - 36 x 18 - 23	-	2 - 3
P. fragosoana Beltran	30 - 43 x 20 - 27	+	4 - 5 E	26 - 39 x 18 - 23	-	3
P. microspora Diet.	23 - 27 x 16 - 21	+	4 - 5 E	28 - 35 x 16 - 21	-	NA
P. posadensis Sacc. & Trott.	28 - 33 x 19 - 25	+	4 - 5 E	36 - 50 x 17 - 20	-	9

Table 8. Details of the rusts recorded on Imperata species and the rust under study (continued)

1	2	3	4	5	6	7
P. infuscans Arth. and Holw.	25 - 32 x 19 - 26	-	3 - 5 E	26 - 46 x 16 - 23	-	9
Rust under study	24 - 36 x 24 - 31	-	5 - 6	Not seen		

The rust under study is distinct from the others recorded on the host genus. Among the rusts recorded, only two species namely, Puccinia imperatae and P. infuscans are aparaphysate. The rust under study is also aparaphysate, but it differs from the above two species in having larger urediniospores, more or less spherical in shape. The germ pores also vary in number; 5 - 6 in the rust under study while they varied from 3-5 in others. The urediniospore wall in the rust under study is uniformly thickened up to 2.5 µ whereas in Puccinia imperatae it is up to 10 µ at the apex. However, in the absence of teliospores in the specimens under study, it is not possible to confidently place the rust under any species. For the present, it is tentatively kept under the form genus Uredo.

The specimens were collected on living leaves of Imperata cylindrica (L.) Beauv. (Gramineae), from Zaria on October 20, 1982.



a. Infected leaves (Imperata cylindrica)



b. Infected leaves (Panicum subalbidum)



c. Urediniospores (from I. cylindrica)



d. Urediniospores (from P.subalbidum)

PLATE X. Uredo sp. nov. on Imperata cylindrica and Uromyces linearis on Panicum subalbidum

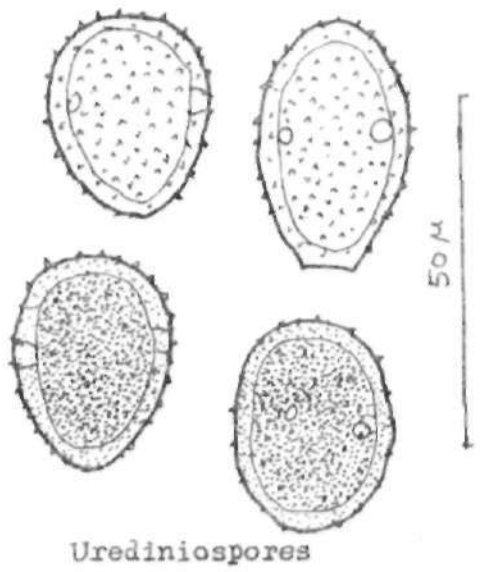


Fig. 12 A PUCCINIA POLYSORA ON ZEA MAYS

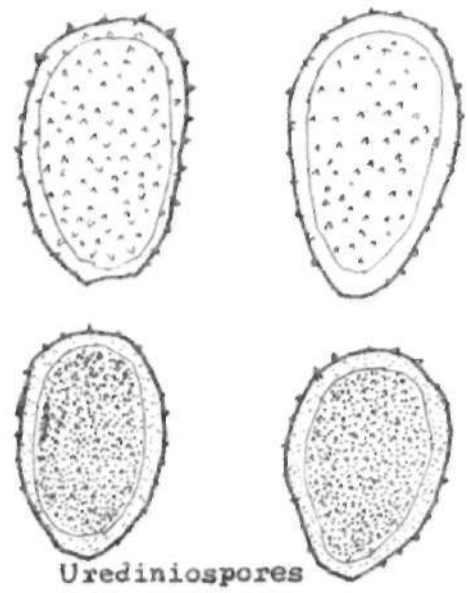


Fig. 12 B PUCCINIA SORGHI ON ZEA MAYS

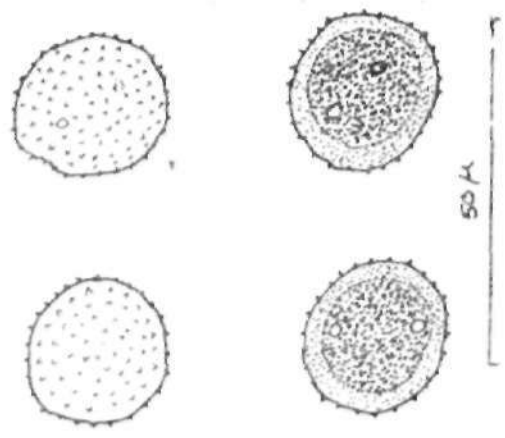


Fig. 12 C UREDO SPECIES NOVA ON IMPERATA CYLINDRICA

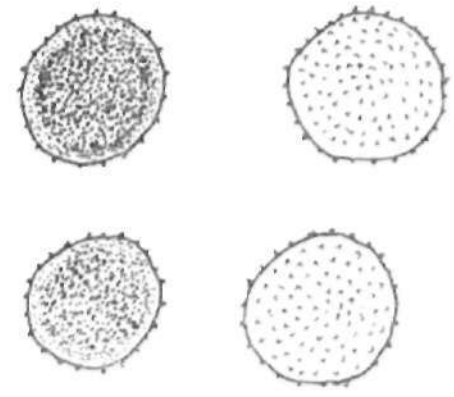


Fig. 12 D UROMYCES LINEARIS ON PANICUM REPENS

11. UROMYCES LINEARIS Berkeley and Broome

(Plate X b ; Fig. 12 d)

Occurrence :

The host Panicum repens L. grows along the field bunds and waste lands where high moisture persists. It is perennial in nature. Likewise, Panicum subalbidum Kunth. is also a perennial grass and thrives well under adequate moisture conditions. However, these grasses dry up under northern Nigerian conditions during January to May. The rust was collected from the two hosts from July up to November. Eboh (1978) recorded the rust on Panicum baumanii K. Schum. from Nsukka (Nigeria).

Description :

Pycnia and necia : Not observed during the studies.

Uredinia : Rust spots inconspicuous on P. repens; dark brown, rectangular, confined between veins running parallel on P. subalbidum: uredinia mostly epiphyllous, narrow, long covered by epidermis except a slit-like opening in the middle, brown; urediniospores globoid, wall thickened upto 3 µ, light brown, finely and closely echinulate, contents golden brown or cinnamon-brown, germ pores 3 (4), approximately equatorial, 26 - 36 x 22 - 28 µ; aparaphysate.

Telia ; Few, epiphyllous, dark brown, exposed, compact; teliospores 1 celled, broadly ellipsoid or globoid, wall uniformly thick at sides up to 4 µ and at apex up to 7 µ, chestnut-brown, smooth, 20 - 33 x 17 - 28 µ, pedicel short, thick walled, yellowish, persistent, not collapsing.

Identification :

Five species of Uromyces have been recorded on the host genus Panicum from a number of countries (Cummins, 1971). The morphological characters and measurements of spores of the recorded species on the host genus are given in Table 9.

Table 9. Details of Uromyces species recorded on Panicum species and the rusts under study.

Rust species	Uredinia			Telia		
	Measurements (in μ)	P	GP	Measurements (in μ)	P	Apex (μ)
Uromyces nitroyensis Rangel	29 - 38 x 20 - 27	+	3 - 4 E	22 - 27 x 14 - 20	-	2.5
U. vossiae Barch.	18 - 24 x 18 - 22	-	3 - 5	24 - 29 x 20 - 24	-	10.0
U. setariae-italicae Yosh.	27 - 33 x 23 - 28	-	3	18 - 25 x 16 - 20	-	1.5
U. graminicola Burr.	20 - 25 x 22 - 26	-	3 - 4 E	23 - 28 x 19 - 26	-	9.0
U. linearis Bork. & Broome	24 - 28 x 22 - 26	-	3 - 4	24 - 29 x 19 - 29	-	8.0
Zaria collections						
on Panicum repens	22 - 32 x 22 - 28	-	3 - 4 E	24 - 32 x 19 - 26	-	8.0
on P. subalbidum	26 - 36 x 19 - 24	-	3 - 4 E	Not observed		

The symptoms and morphological characters and measurements of the spores from the two hosts closely resemble those of U. linearis.

The first record of this rust was made by Berkeley and Broome (1875) from Peradeniya, Sri Lanka on Panicum repens the specimens of

which were collected by Thwaites in March, 1868. Panicum subalbidum is a new host for this rust.

The rust specimens were collected from Samaru on living leaves of Panicum repens and P. subalbidum Kunth. (Gramineae) on October 23, 1982.

12. PHAKOPSORA APODA (Harar and Patouillard) Mains

(Plate XI ; Fig. 13)

Occurrence :

Pennisetum pedicellatum Trin. is a common grass having very colourful flowers growing in many parts of Nigeria. It grows luxuriantly during the wet season and provides a source of cattle fodder. The rust appears on the host prominently during September onwards and continues till the grass dries up in November- December due to the dry season. The same rust was collected by Eboh (1978) on P. polystachyon (L.) Schult. from Nsukka (Nigeria) in its uredinial stage. The rust collected on P. pedicellatum produces uredinia and telia profusely.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Rust spots prominent, epiphyllous, minute, round, yellowish; uredinia isolated or in groups, amphigenous, erumpent, oval, epidermis rupture early, spore mass golden yellow; urediniospores ellipsoid, or obovoid, sometimes spherical, thin walled up to 1 µ, contents yellowish, surface finely echinulate, germ pores 5 - 8, scattered, 24 - 35 x

19 - 24 u; paraphyses numerous, marginal, incurved, hyaline to yellowish, 60 u long, apically thickened up to 10 µ.

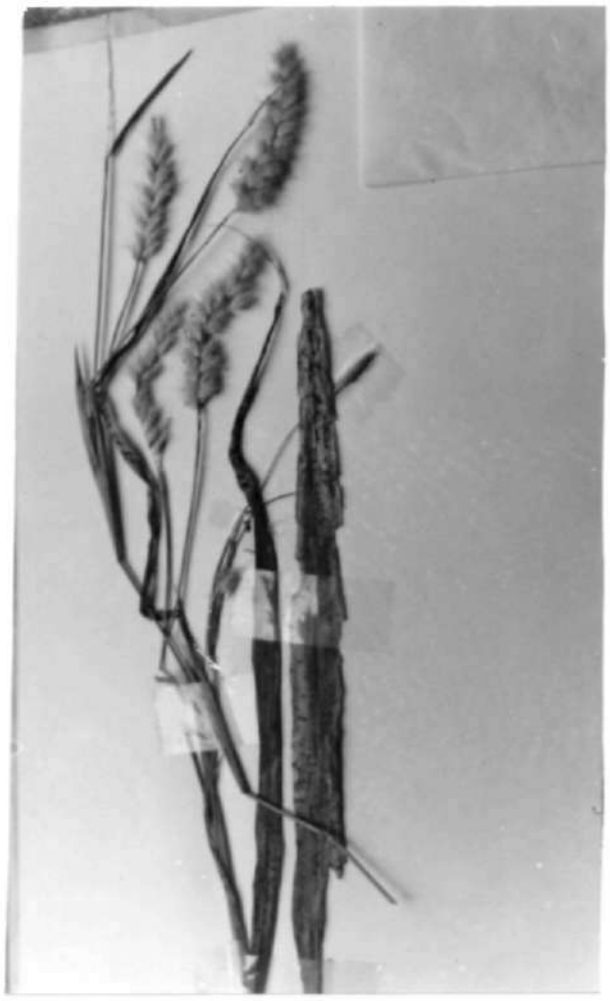
Telia : Numerous, in patches, covered by epidermis, dark brown to blackish, shining surface, prominent on the lower surface, crustose; teliospores in 3 - 5 layers, loosely attached on sides, ellipsoid or obovoid, sides angular, wall up to 2 u thick at sides and up to 5 µ at apex, golden to chestnut brown, with pne or more apical germ pores, 14.5 - 28.0 x 14.5 x 19,0 µ.

Identification :

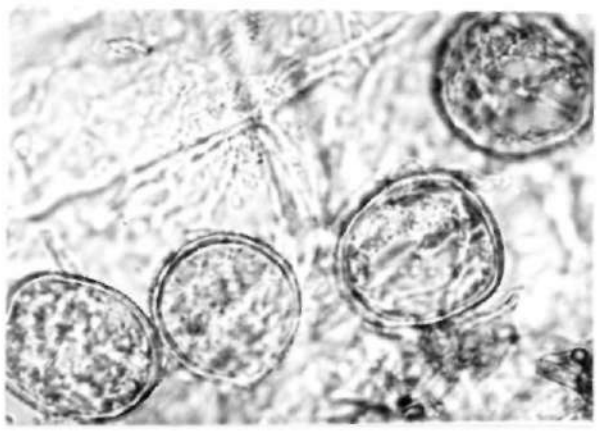
A single species of Phakopsora has been recorded so far on this host genus. A careful comparision of the morphological characters and spore measurements of the rust under study with the original description of Phakopsora apoda showed that the two rusts are one and the same. The details of the spore characters and measurements of the rust under study as well as the original one are given in Table 10.

Table 10. Details of the spore characters of Phakopsora apoda from different collections

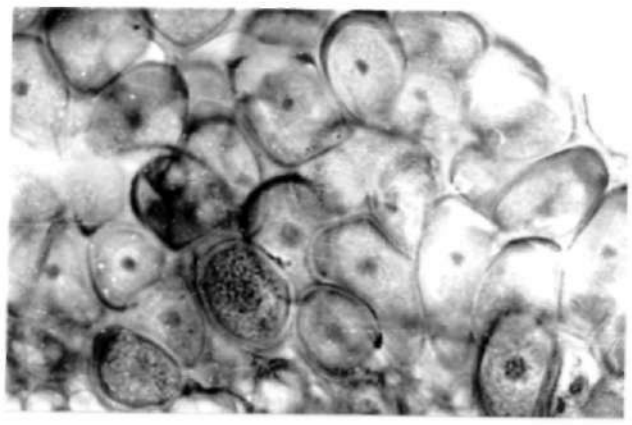
Rust collections	Uredinia			Telia		
	Measurements (µ)	P	GP	Measurements (µ)	P	Apex (u)
Phakopsora apoda (original)	24 - 34 x 18 - 23	+	5 - 8 S	16 - 32 x 14 - 20	-	5
Nigerian collections						
on Pennisetum polystachyon (by Eboh)	23 - 33 x 21 - 24	+	4 - 8 S	Not seen by Eboh		
on P. pedicellatum (Rust under study)	23 - 33 x 19 - 24	+	5 - 8 S	15 - 30 x 14 - 19	-	5



a. Infected plant



b. Urediniospores



c. Teliospores (in group)



d. Teliospores (section)

PLATE XI. Phakopsora apoda on Pennisetum pedicellatum

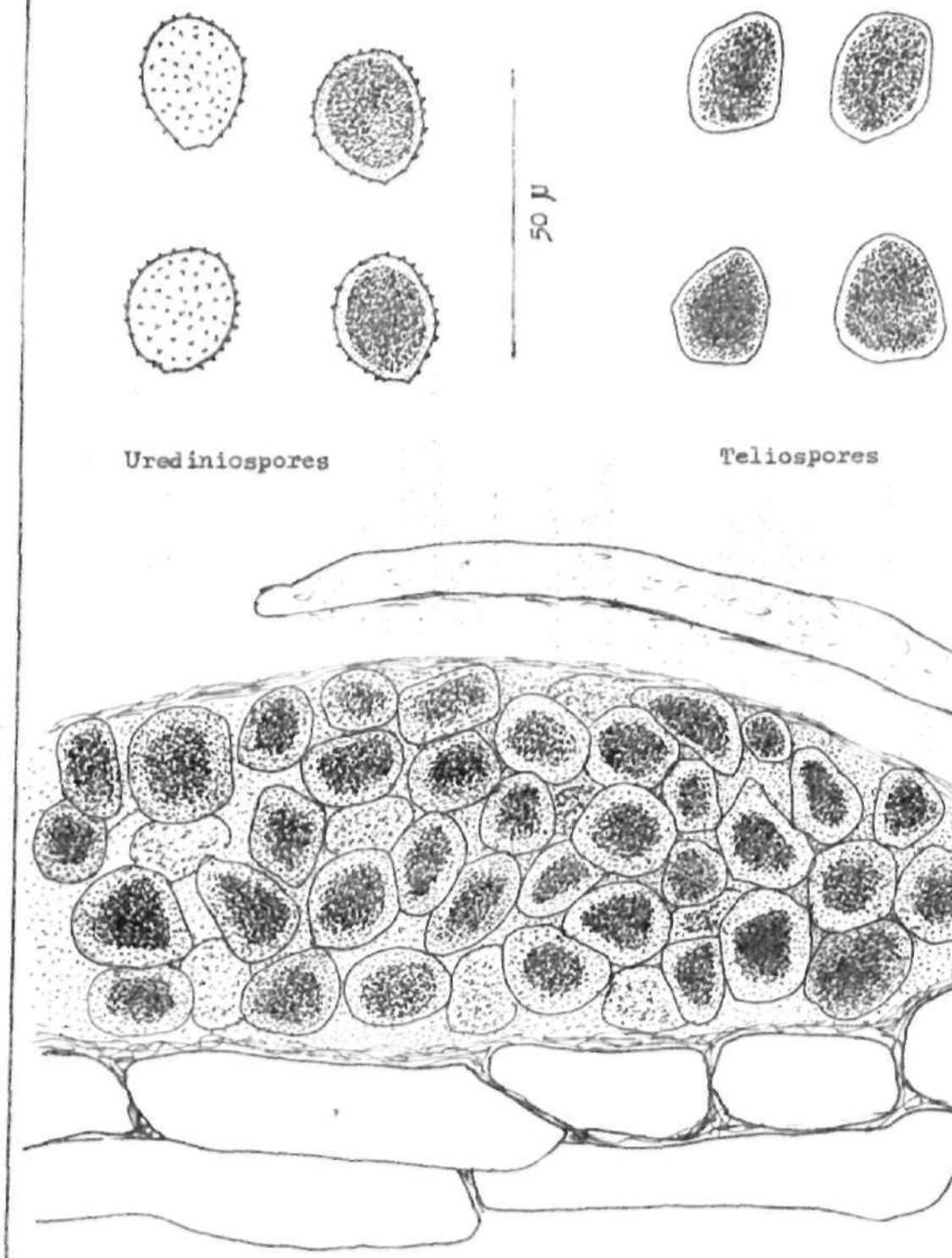


Fig. 13 PHAKOPSORA APODA ON PENNISETUM PEDICELLATUM

The rust was originally recorded by Harar and Patouillard (1909) based on the specimens collected by Chevalier on Pennisetum setosum (Swartz) L. Rich. from Port Lamy, Chari, French Congo as Puccinia apoda which was later transferred to the genus Phakopsora by Mains (1938). The rust has a wider distribution in many African countries on the hosts Pennisetum pedicellatum, P. polystachyon, and P. setosum.

The rust specimens were collected on living leaves of Pennisetum pedicellatum (L.) Schult. (Gramineae) from Samaru on October 16, 1982.

PUCCINIA SUBSTRIATA Ellis and Bartholomew var. penicillariae Ramachar and Cummins

(Plate XII ; Fig. 4)

Occurrence :

Pearl millet (Pennisetum americanum (L.) K. Schum. is a common staple food in Africa and India. The rust disease occurs wherever the crop is grown. In Nigeria, it is present in all the millet growing areas. In Zaria, the rust appears during August and continues up to the harvest of the crop in October - November. It was also observed on the irrigated crop (planted in January - February) during March - April in Samaru.

Description :

The complete life cycle of the rust was worked out during the studies. The pycnia and aecia occur on Solanum melongena and on a variety of the same species ex Ogunmu in Nigeria. The detailed study of the same has been described elsewhere in this thesis (p. 160 - 63)

Pycnia and aecia : Spots minute, yellowish to start with, isolated and scattered, enlarge in size with age; pycnia epiphyllous, dot-like, erumpent, subepidermal in origin, honey-brown, shining with sugary exudate, in groups, spherical to flask shaped, flexuous hyphae elongated and formed along the margin, yellowish brown, 110 x 140 µ ; aecia cupulate, surrounded by white, lacerated peridium, orange-yellow, in groups, mostly hypophyllous; aeciospores light orange, wall thin, hyaline, surface with fine markings, spherical to obovate, slightly angular sides, catenulate, borne on short stalks; peridial cells polygonal, hyaline, surface strongly echinulate on free surface.

Uredinia : Rust spots isolated or in groups, epidermis usually rupture early; urediniospores broadly ellipsoid to obovate, thin walled, light brown, echinulate, contents cinnamon-brown, germ pores 4 (5), equatorial, 24 - 36 x 19 - 26 µ.

Telia : Isolated or formed on older uredinia, epidermis covered in the initial stage, dark brown to blackish, erumpent, aparaphysate; teliospores 2 - celled, mostly oblong to ellipsoid, or clavate, wall 2 - 3 µ thick at sides, 4 - 8 µ apically, chestnut-brown, smooth, 48 - 72 x 17 - 24 µ;

pedicel yellowish, thin walled, short.

Identification :

Cummins and Ramachar (Cummins, 1971) after careful studies of various type specimens and other collections of rusts on Pennisetum species and allied hosts finally decided on four varieties under P. substriata which name they retained instead of P. penniseti Zimm., P. penicillariae Speg., and P. penneseti - spicati Petrak, all were recorded on Pennisetum americanum (typhoides). The details of the rusts recorded on P. americanum , other species and allied hosts are given in Table 11.

Table 11. Details of rusts recorded on the genus Pennisetum

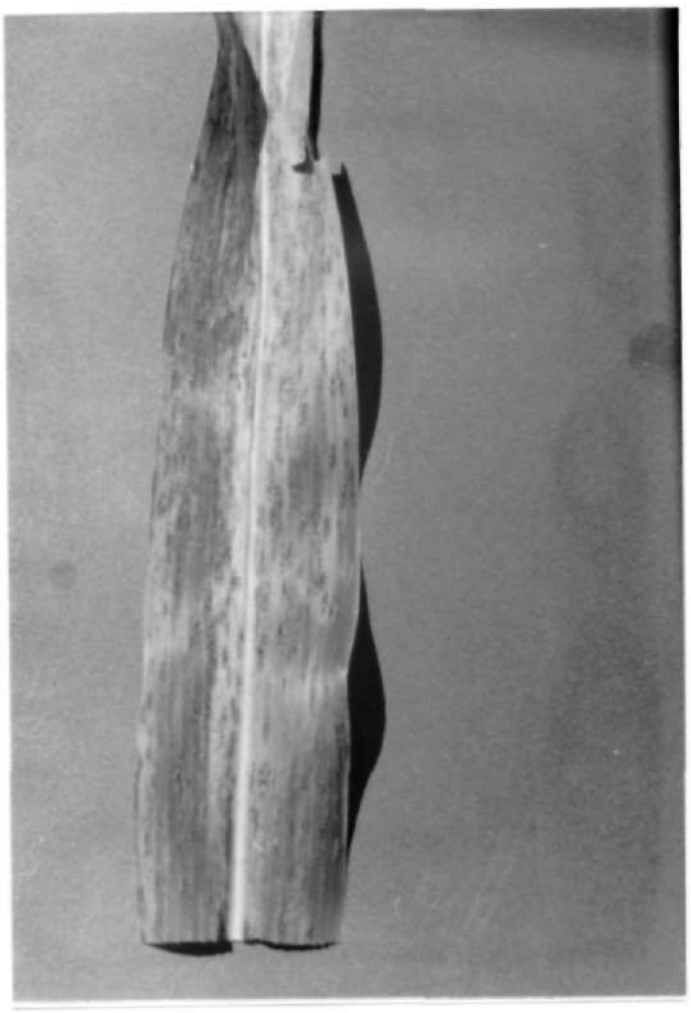
	Uredinia			Telia		
	Measurements (in µ)	P	GP	Measurements (in µ)	P	Apex (µ)
Puccinia substriata var. substriata Ell.& Berk.	23 - 37 x 18 - 23	-	3 - 5 E	29 - 50 x 20 - 29	-	3 - 7
P.substriata var. penicillariae (Speg)Ramachar & Cummins	34 - 46 x 19 - 26	-	4 - 5 E	34 - 65 x 20 - 27	-	4 - 8
P.substriata var. indica Ramachar & Cummins	25 - 34 x 20 - 28	-	3 - 5	41 - 71 x 14 - 24	-	4 - 8
P.substriata var. ingolita Syd.)Ramachar & Cumm.	26 - 42 x 20 - 29	-	3 - 5 E	27 - 48 x 17 - 24	-	3 - 6
Rust under study	24 - 36 x 19 - 26	-	4 - 5	48 - 72 x 17 - 24	-	4 - 8

The rust under study closely resembles in its morphological and spore measurements, P. substriata var. penicillariae recorded on pearl millet earlier and was therefore identified it as such.

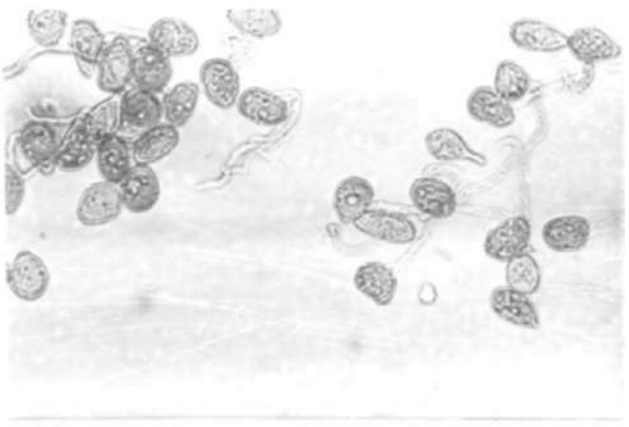
The first collection of the rust P. penniseti was made by Spegazzini (1914) from Dakar (Senegal) and he described it as P. penicillariae. Zimmerman (1904 - 6) had earlier described the rust collected from Pennisetum typhoides as P. penniseti. Recently, Petrack (1959) described another species namely, P.penniseti-spicati (Cummins, 1971) after a detailed study of the rusts recorded on Pennisetum and allied hosts revised their taxonomic position, the details of which are given in Table 12.

Table 12. Details of hosts recorded for Puccinia substriata and varieties

Rust species	Hosts	Countries
Puccinia substriata var, substriata	Species of Digitaria, Paspalum and Setaria	U S A, Panama, Brazil, Bolivia, Trinidad & Hawaii
P. substriata var. penicillariae	pennisetum americanum and Beckeropsis uniseta	Africa and Madagasgar
P.substriata var. indica	Pennisetum americanum	India
P. substriata var. insolita	Panicum antidotale P. maximum, Setaria barbata, S. orthostica and S. sphacelata	Equatorial Africa



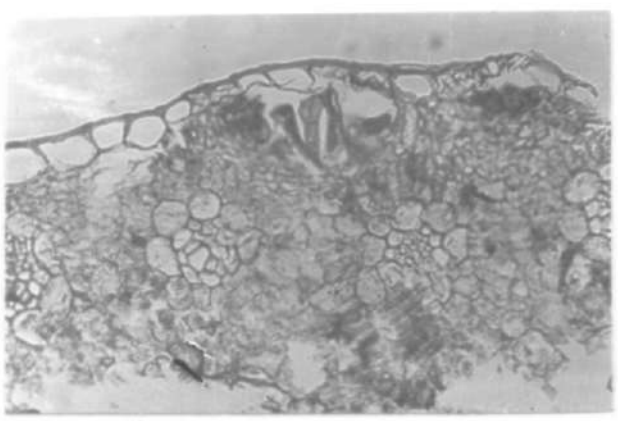
a. Infected leaf



b. Urediniospores (germination)



c. Urediniospores and Teliospores



d. Teliospores (section)

PLATE XII. Puccinia substriata var. penicillariae on Pennisetum americanum

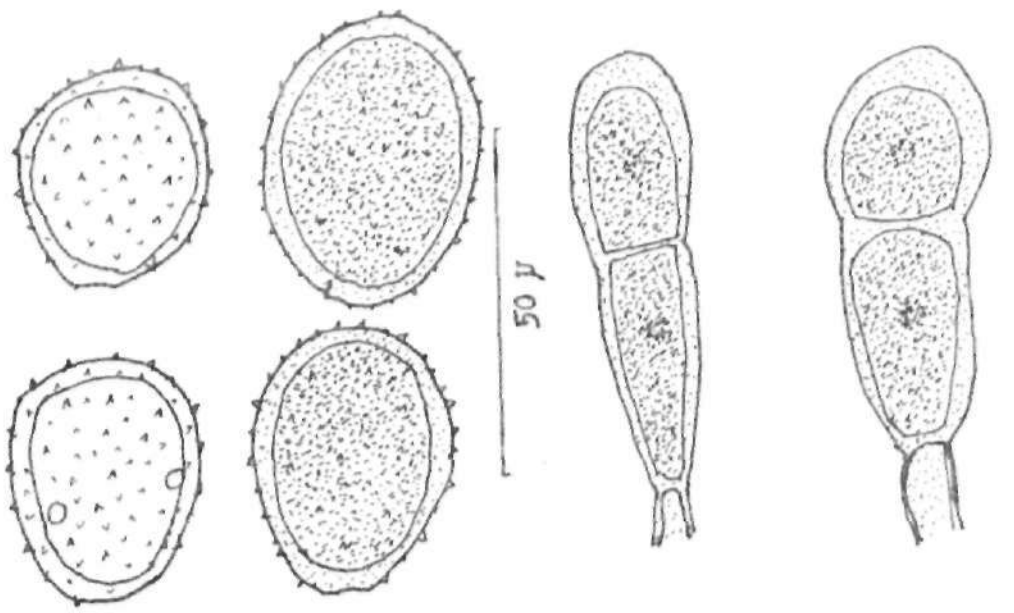


Fig. 14 PUCCINIA SUBSTRIATA VAR. PENICILLARIAE ON PENNISETUM AMERICANUM

14. UROMYCES SETARIAE - ITALICAE Yoshin

(Plate XIII ; Fig. 15 & 16)

Occurrence :

The rust was collected from four different hosts namely, Setaria pallede-fusca (Schu.) Stapf,& C.E.Hubb., Brachiaria stigmatisata (Mez.) Stapf, B. lata (Schu.) C.E.Hubb,, B. brizantha (Hochst. ex A.Rich.). The hosts are common grass weeds growing in the cultivated and waste lands in most of the tropical countries. In Nigeria, these grasses grow all over the country. The rust appears on the hosts from June and continues till they dry up in winter months.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Rust spots minute, yellowish surrounded by green island, numerous, scattered; uredinia scattered, minute, epidermis ruptures early, light brown, spores spherical to oblong, obovate, wall uniformly thickened up to 2 µ, finely echinulate yellowish brown, contents yellowish to dark brown, germ pores prominent, 3 (4), equatorial, 28.8 x 24.0 µ (26.4 - 32.2 x 21.6 - 26.4).

Telia ; Amphigenous on leaves, epiphyllous on leaf sheath and young stem, covered by epidermis, blackish with shining surface; spores 1 - celled, angularly globoid or obovoid, wall thin up to 1.5 µ, light brown, smooth, spore contents clear, brown, 24 x 21.2 µ (22.5 - 28.4 x 19.2 - 24.0), pedicel colourless, thin walled, up to 20 µ but often broken near the base.

Identification :

Two species of Uromyces have been recorded on the genus Setaria and allied hosts. The comparative characters including the spore measurements are given in Table 13.

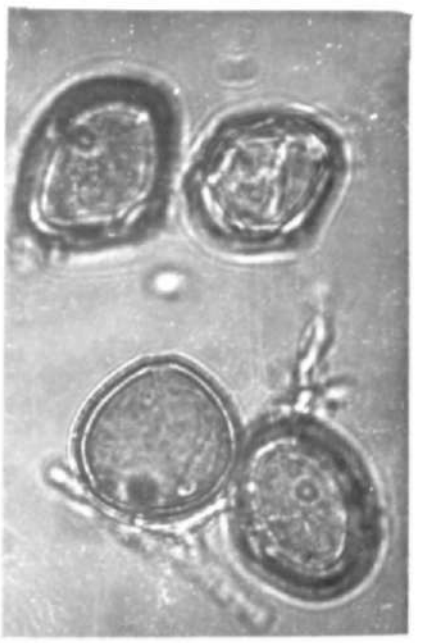
Table 13. Details of Uromyces species recorded on species of Setaria and Brachiaria compared with the rust under study.

Rust species	Uredinia			Telia	
	Measurements (in μ)	P	GP	Measurements (in μ)	P
U. setariae-italicae Yosh.	25 - 35 x 20 - 30	-	3 E	16 - 28 x 14 - 20	-
U. nitroyensis Rasogel	26 - 42 x 20 - 27	+	3 (4) E	19 - 30 x 14 - 20	-
Rusts under study					
on Setaria pallide-fusca	20 - 27 x 16 - 25	-	3 E	19 - 24 x 12 - 16	-
Brachiaria lata	22 - 25 x 17 - 24	-	3 E	19 - 24 x 17 - 24	-
B. stigmatisata	23 - 32 x 18 - 28	-	3 E	19 - 28 x 14 - 20	-
B. brizantha	24 - 29 x 19 - 24	-	3 E	18 - 22 x 14 - 20	-

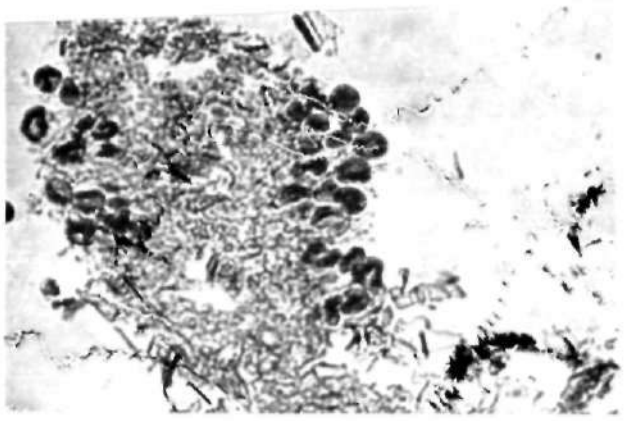
The rusts collected from all the four grasses closely resemble the original descriptions of Uromyces setariae - italicae in spore characters and measurements, absence of paraphyses, similarity in spore shape, colour and number and distribution of germ pores in the urediniospores.



a. Setaria pallide-fusca
(infected leaves)



b. Urediniospores



c. Uredinium (section)



d. Teliospore

PLATE XIII. Uromyces setariae - italicae on Setaria pallide-fusca

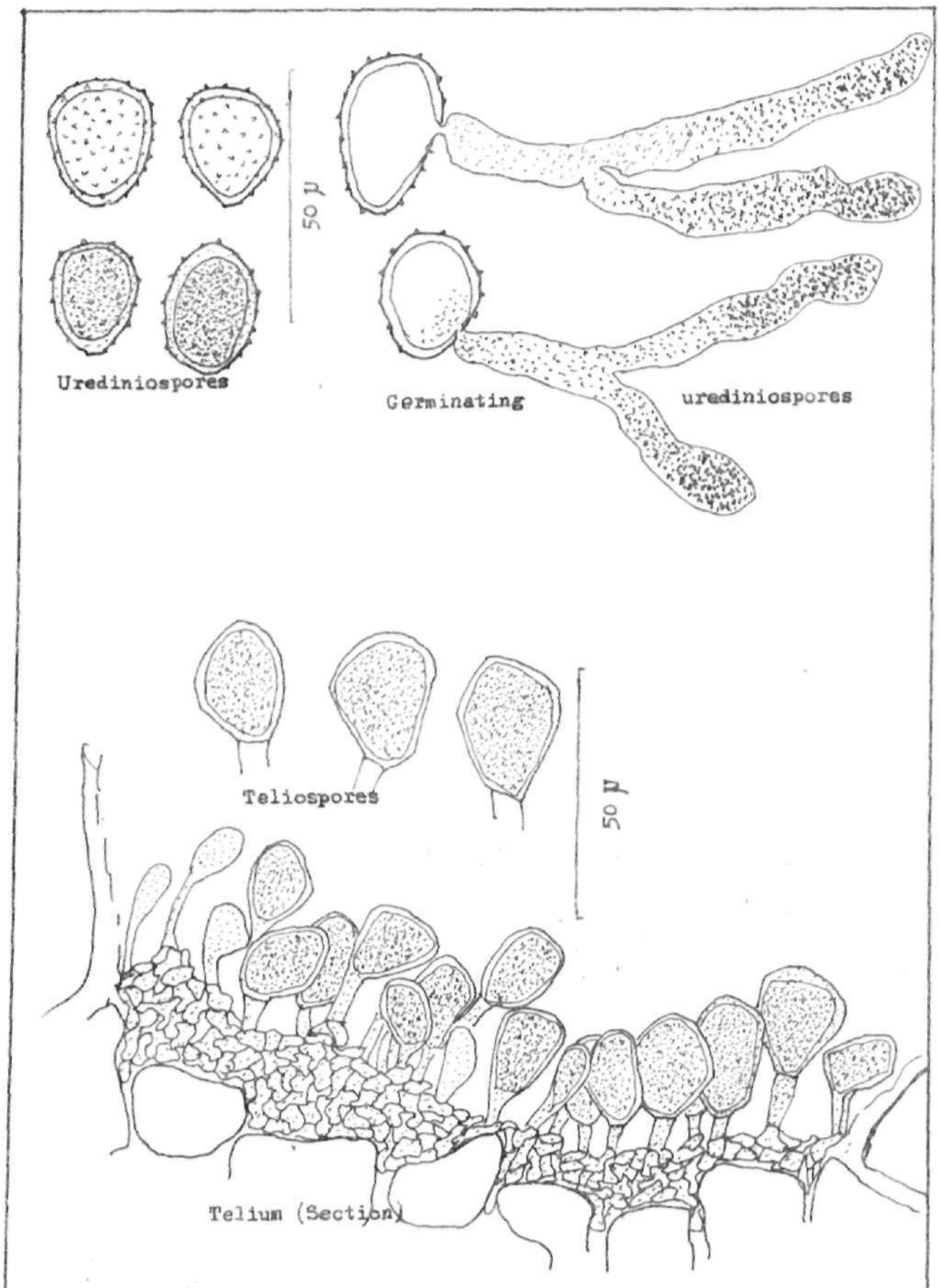
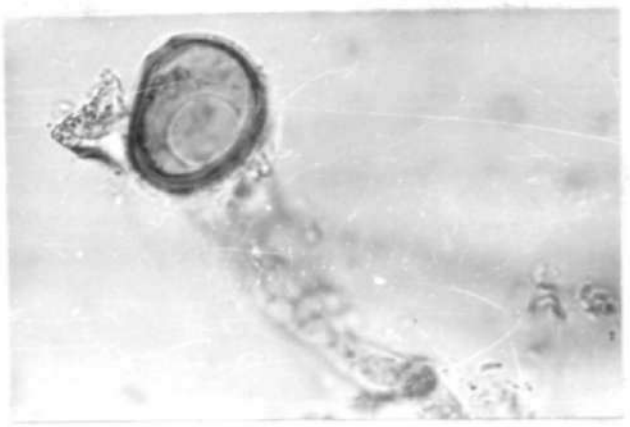


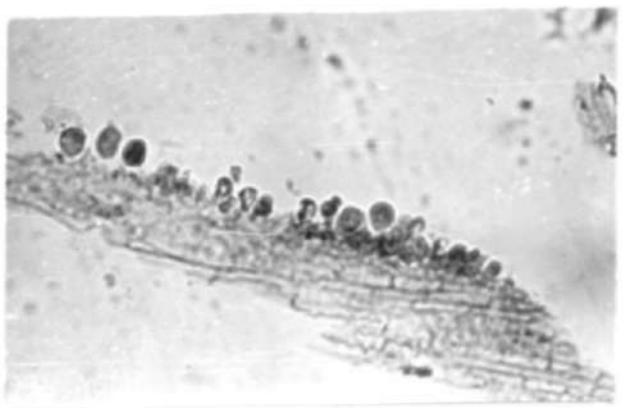
Fig. 15 UROMYCES SETARIAE-ITALICAE ON SETARIA PALLIDEFUSCA



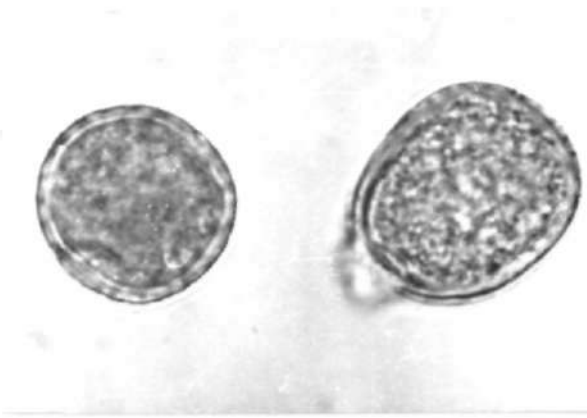
a. Brachiaria lata (infected leaves)



b. Urediniospores (germination)



c. Uredinium (section)

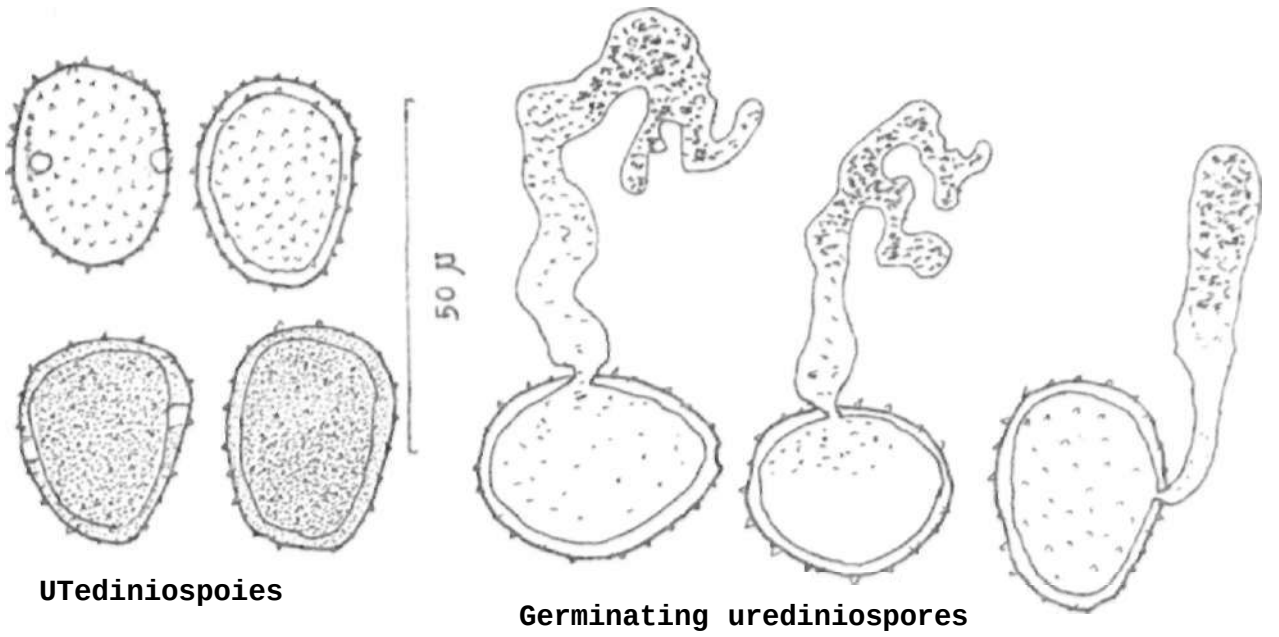


d. Urediniospores (from B.brizantha)



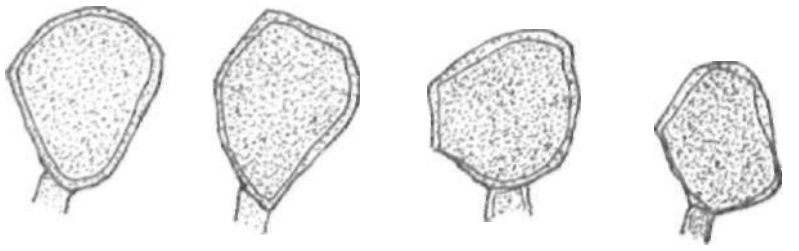
e. Urediniospores (from B.lata)

PLATE XIV. Uromyces setariae-italicae on Brachiaria brizantha and B. lata

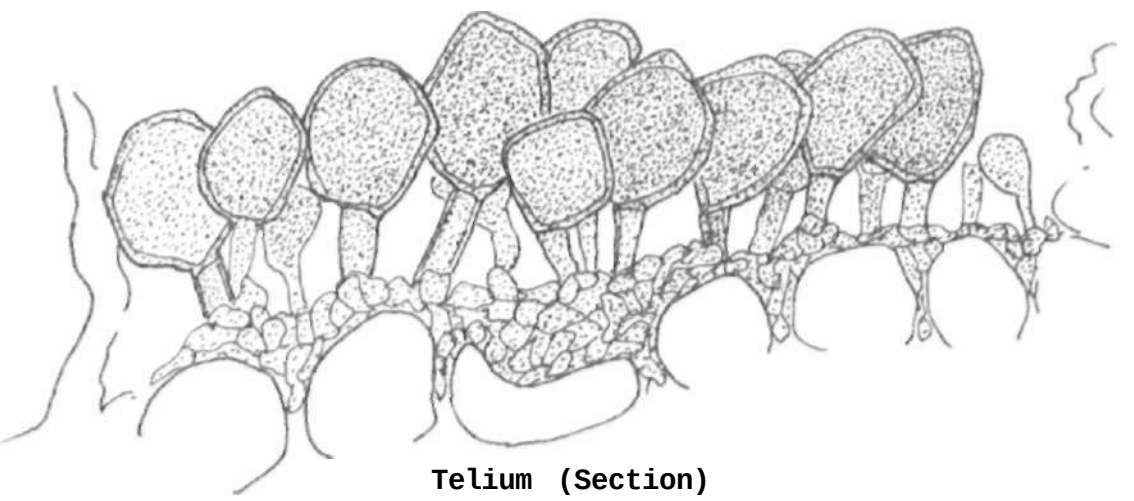


UTediniospoies

Germinating urediniospores



Teliospores



Telium (Section)

Fig.1'6 UROMYCES SETARIAE-ITALTCAE ON RRACHIARIA STIGMATISATA

Yoshin (1906) described the fungus for the first time on the host Setaria italica (L.) Beauv. collected from Kumamoto, Japan. Later, the same was described from many other countries (Cummins, 1971). Eboh (1978) reported the rust on Brachiaria and Panicum species. Narasimhan and Thirumalachar (1964) reported the life cycle connoting Aecidium brasiliense Diet. on Cordia sp. from India.

Germination :

Freshly collected urediniospores floated on water drops and subjected to high humidity germinated within 3 hours. Normally 2 germ tubes came out through the pores, one on each side. The germ tubes were short and stout in the begining but became elongated and often curled. Attempts made to germinate teliospores were not successful.

The specimens were collected on living leaves of Setaria pallide-fusca (Sch.) Stapf & C.E.Hubb., Brachiaria stigmatisata (Mez.) Stapf, B. lata (Sch.) C.E.Hubb. and B. brizantha (Hochst) Stapf (Graminea) from Zaria, on November,12, 1982.

15. URONYCES TENUICUTIS McAlpine

(Plate XV ; Fig. 17)

Occurrence :

Sporobolus pyramidatus (Lam.) Hitche is a perennial grass growing along the field bunds and waste lands throughout Nigeria. It can remain green for most parts of the year provided sufficient soil moisture is available. Rust appears in its uredinial stage from June onwards followed by telial formation from July till the host dries up. Eboh (1978) recorded this rust on the same host from Nsukka (Nigeria).

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia ; Rust spots irregular, brown, amphigenous, scattered, or confluent; sori epiphyllous, cinnamon-brown, linear, covered by epidermis except a slit-like opening in the middle; spores obovate, oblong or spherical with uniformly thickened wall, up to 2 µ, echinulate, light brown, germ pores 3 - 5, obscure but equatorial, 14 - 24 x 20 - 30 µ; aparaphysate.

Telia : Sori isolated or mixed with uredinia, amphigenous, covered by epidermis; spores 1 - celled, obovoid, or ovate, occassionally varying in shape, wall uniformly thick at sides up to 2 µ and up to 6 µ at apex, smooth, contents chestnut-brown, 22 - 29 x 14 - 22 u; pedicel persistent, thin walled, up to 35 µ long; paraphysate, paraphyses clavate, light brown, measure up to 65 µ.

Identification :

Three species of Uromyces have been so far recorded so far from different countries on the host genus Sporobolus. The morphological characters and spore measurements are given in Table 14.

Table 14. Details of Uromyces species recorded on the genus Sporobolus and the rust under study

Rust species	Uredinia			Telia		
	Measurements (in μ)	P	GP	Measurements (in μ)	P	Apex (μ)
Uromyces sporoboli-	30 - 35 x	-	2 - 3	26 - 34 x	-	9
cola Lindq.	25 - 29		E	17 - 23		
U. sporoboli E.& Ev.	36 - 40 x	-	4 - 5	35 - 40 x	-	10
	26 - 32		E	24 - 28		
U. tenuicutis McAlp.	24 - 30 x	-	3 - 5	22 - 28 x	+	5
	19 - 23		E	16 - 23		
Rust under study :	24 - 32 x	-	3 - 5	22 - 29 x	+	6
	20 - 30		E	14 - 22		

The first record of the rust was made by McAlpine (1906) based on the specimens collected by Robinson on Sporobolus indicus (L.) R.Br. from the suburbs of Melbourne, Australia. Later, the same was collected from several other countries (Cummins, 1971).

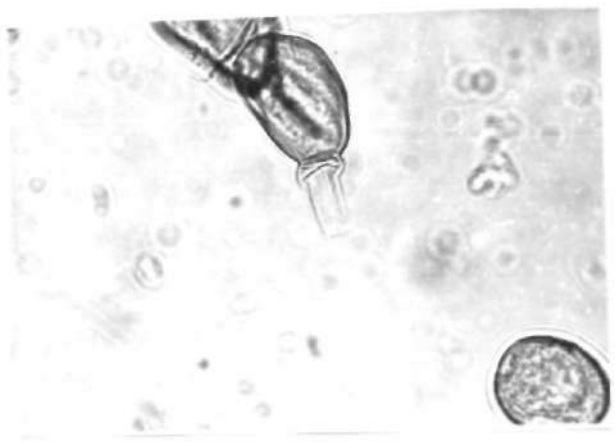
The specimens were collected on living leaves and stems of Sporobolus pyramidatus (Lam.) Hitchc (Gramineae ,, from Zaria on October 21, 1982.



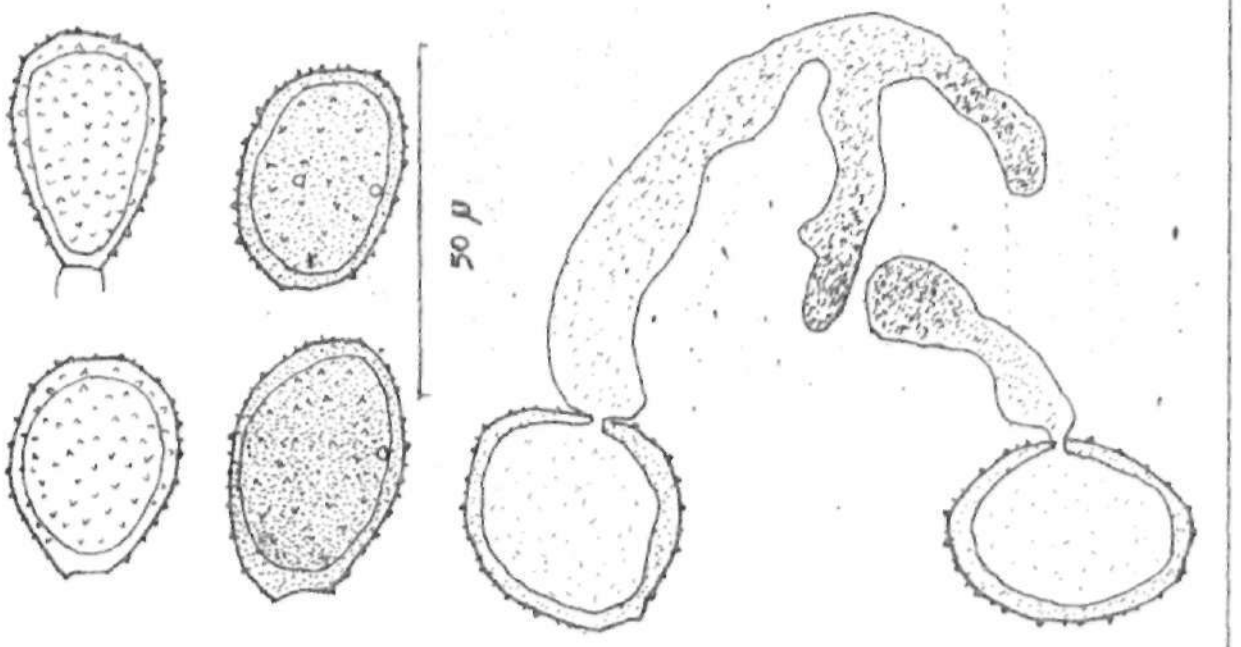
a. Infected leaves

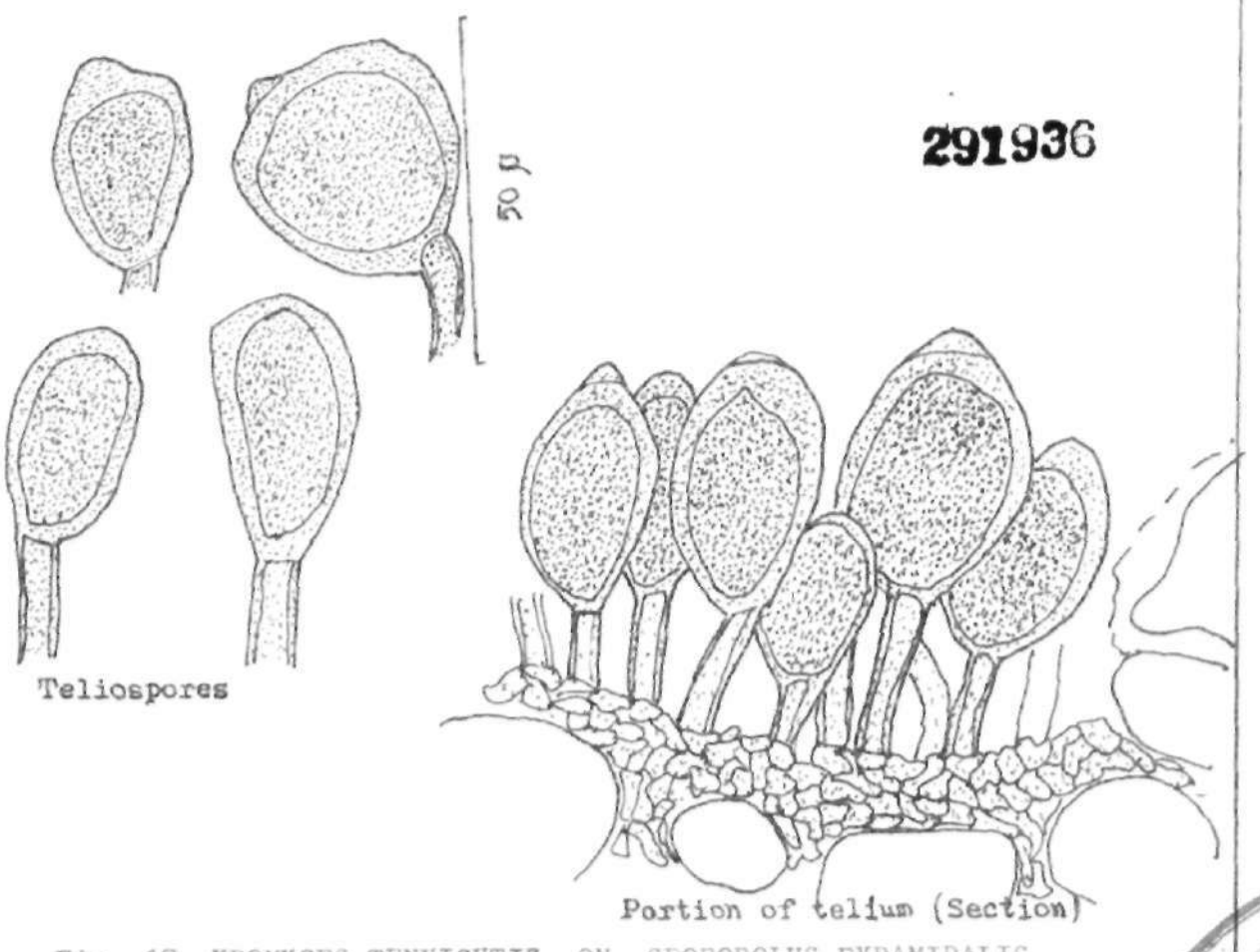


b. Urediniospores



c. Teliospores





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Fig. 17 UROMYCES TENUICUTIS ON SPOROBOLUS PYRAMIDALIS

RECEIVED

16. PUCCINIA POLYSORA Underwood

(Plate XVI ; Fig. 12 a)

Occurrence :

This rust occurs commonly on maize (Zea mays L.) cultivated as a staple food in Nigeria. The rust appears in its uredinial stage from September and assumes a serious proportion in October onwards especially on late sown crop under Zaria conditions. Most of the cultivars in Zaria were found to be affected by the rust though the intensity of infection varied with the variety. The telial stage was not observed during the course of this study. This rust has been reported from many parts of Nigeria (Eboh, 1978; Emechebe et al., 1980)

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Sori numerous, isolated, amphigenous, long covered by the epidermis, light cinnamon-brown in colour, spherical, up to 2 mm in diam, in severe case covering the entire leaf area; urediniospores yellowish to golden brown, spherical to ovoid and measure 22 - 30 x 28 - 38 µ, wall uniformly thickened up to 2 µ, minutely echinulate, germ pores 4 - 5, equatorial; aparaphysate.

Telia : Not observed during the studies. The same were not also recorded by others so far from Nigeria.

Identification :

The rust under study closely resembles Puccinia polysora recorded on this host from many coubtries in the past.The measurements of the urediniospores, the position of germ pores and their number observed from the collections made from Zaria are compared with the original in Table 15.

Table 15. Comparative characters of Puccinia polysora and the rust under study

Rust species	Uredinia			Telia		
	Measurements (in µ)	P	G P	Measurements (in µ)	P	Apex (µ)
Puccinia polysora	29 - 36 x 23 - 29	-	4 - 5 E	29 - 41 x 20 - 27	-	2
Rust under study :	22 - 30 x 24 - 28	-	4 - 5 E	Not observed		

The first record of this rust was made by Underwood (1897) based on the specimens collected by Duggar on the host Tripsacum dactyloides (L.) from Auburn, Alabama, USA.

The specimens were collected on living leaves of Zea mays L. (Gramineae) from Zaria on October 15, 1982.



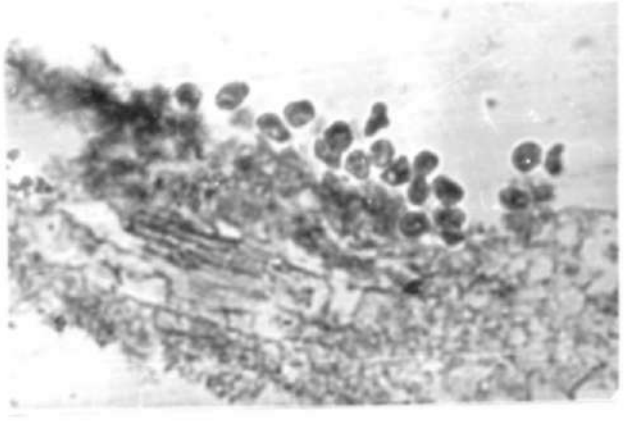
a. Infected leaf



b. Urediniospore (germination)



c. Urediniospores



d. Uredinium (section)

PLATE XVI. Puccinia polysora on Zea mays

17. PUCCINIA SORGHI Schweinitz

(Plate XVII ; Fig. 12 b)

Occurrence :

The rust disease generally appears during September and continues till the harvest of the crop. The severity of incidence depended on the amount and distribution of rainfall. A drier weather will reduce the incidence of the rust.

Description :

Pycnia and aecia : Not observed during the studies;

Uredinia : Spots circular to elongate, golden brown to cinnamon-brown, becoming darker with maturity, epidermis burst open exposing dark brown powdery mass of spores, more sori become confluent forming large patches; spores cinnamon-brown, broadly ellipsoid, or broadly obovate or spherical, wall uniformly thick up to 2 µ, echinulate, germ pores 3 - 4, equatorial, 24 - 32 x 20 - 29 µ; aparaphysate.

Telia : Not observed during the studies.

Identification :

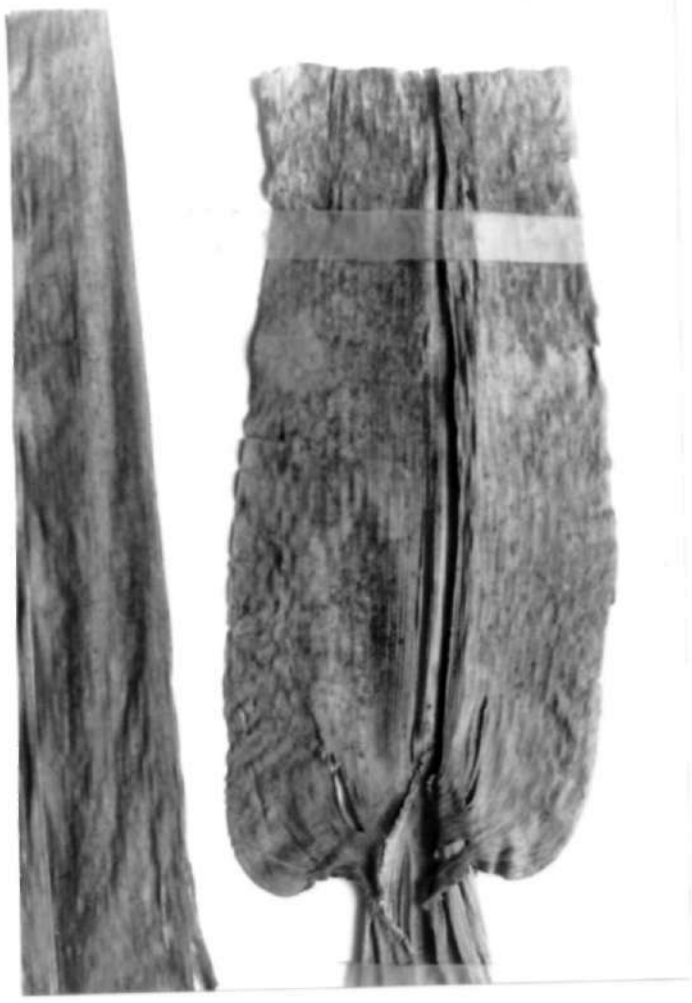
The rust under study closely resembles Puccinia sorghi recorded on this host from many countries in the past (Cummins, 1971). The morphology and the spore measurements of the rust under study are compared with P. sorghi in Table 16.

Table 16. Comparative characters of Puccinia sorghi and the rust under study

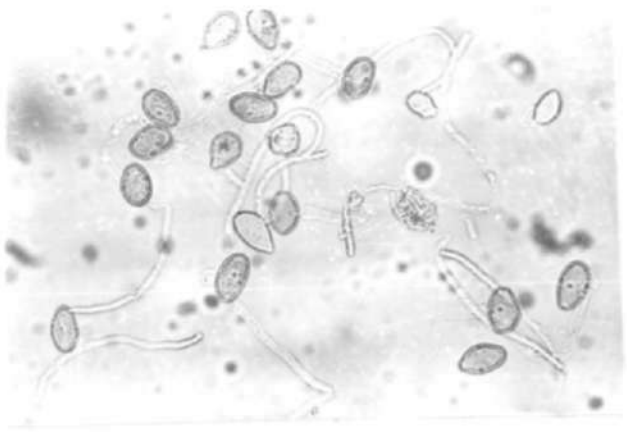
Rust species	Uredinia			Telia		
	Measurements (in μ)	P	G P	Measurements (in μ)	P	Apex (μ)
Puccinia sorghi	26 - 31 x 24 - 28	-	3 - 4 E	30 - 42 x 18 - 23	-	4 - 9
Rust under study	24 - 32 x 20 - 29	-	3 - 4	Not obsebved		

Puccinia sorghi differs from P.polysora in having larger sori and the epidermis burst open early. The shape and the spore size in both the species recorded on maize widely differ. The first record of this rust was made by Schweinitz (1832) on Zea mays collected from Bethlehem, Pennsylvania, USA. Arthur (1904) demonstrated the life cycle of the rust by inoculation connecting Aecidium oxalidis Theum. on species of Oxalis.

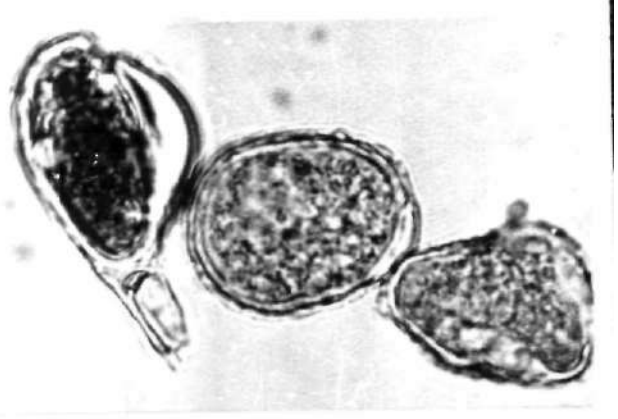
The specimens were collected on living leaves of Zea mays L. (Gramineae), from Zaria, on October 25, 1982.



a. Infected leaves



b. Urediniospores (germination)



c. Urediniospores

PLATE XVII. Puccinia sorghi on Zea mays

18. AECIDIUM JASMINI Berkeley

(Plate XVIII ; Fig. 18)

Occurrence :

The host Jasminum dichotamum L. is an evergreen creaper growing along the streems and perennial water sources. The rust was collected on this host from August through December when new shoots and leaves were abundant. The pycnia and aecia were observed during the studies.

Description :

Pycnia and aecia : Rust spots prominently formed on young leaves, petioles and tender stem. On leaves, gall-like formation is seen. Affected areas of the leaf becomes thickened, turn concave on the upper surface and convex on the lower surface. Pycnia epiphyllous, flask shaped, with ostiolar paraphyses, pycniospores numerous, small, oval, oozing out through the ostiole. Aecia cupulate, with marginal, lacerated peridial wall; aeciospores brilliant orange, powdery, spherical, thin walled, wall colourless, contents bright orange, finely verruculose, 20 - 26 µ; peridium single layer, cells hexagonal, 26 x 22 µ, thick walled, closely and strongly echinulate on free surface.

Identification :

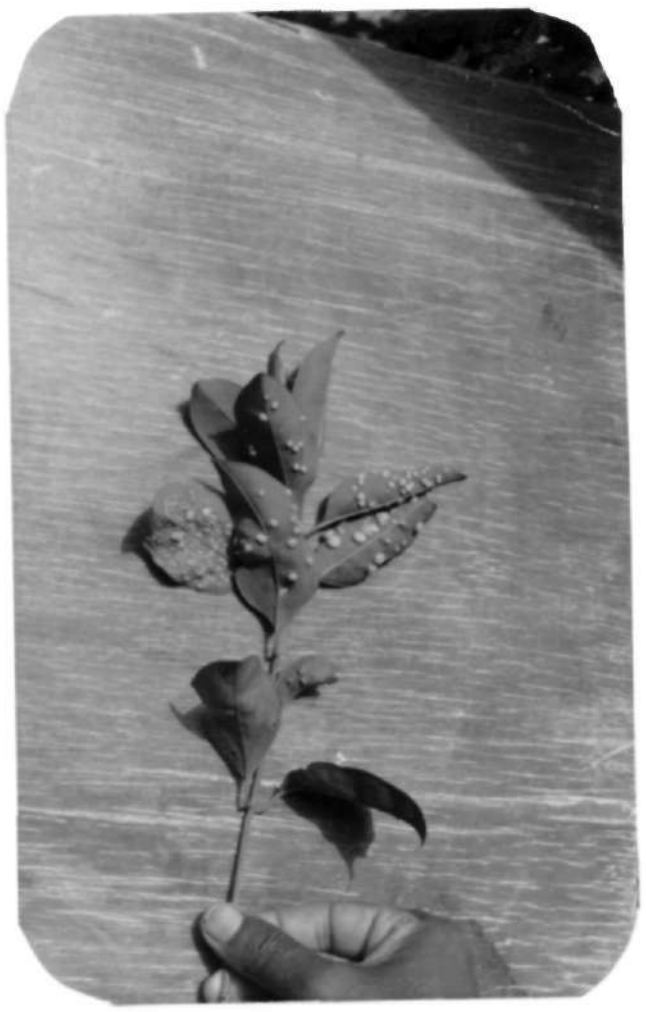
Four rusts have been recorded on this host genus from different parts of the world. The details of the rust species, their characters and spore measurements are given in Table 17.

Table 17. Details of rusts recorded on Jasminum species and the rust under study

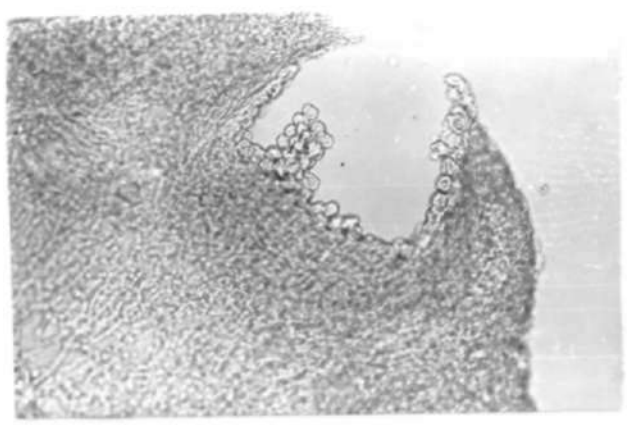
Rust species	Aeciospore (in μ)	Surface	Wall (μ)
Puccinia chrysopogi Baul	23 - 28	Verrucose	Thin
P. jasminicola P.Henn.	16 - 20 x 13 - 17	Verruculose	1.0
Aecidium jasmini Berk.	26.2 x 20.2	No marking	Thin
Rust under study	26 - 20	No marking	Thin

The rust under study closely resembles Aecidium jasmini recorded on this host early by Berkeley (1891) from Simla (India). There is no record of this rust from Nigeria.

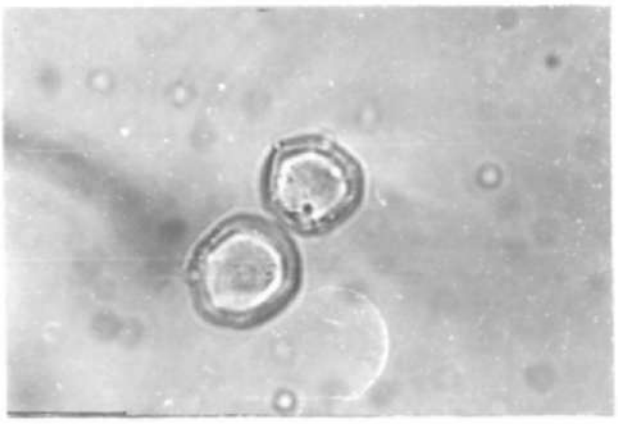
The specimens were collected on the living leaves of Jasminum dichotamum L. (Jasminaceae) from Zaria on October 11, 1982.



a. Infected plant



b. Aecium (section)



c. Aeciospores

PLATE XVIII. Aecidium jasmini on Jasminum dichotomum

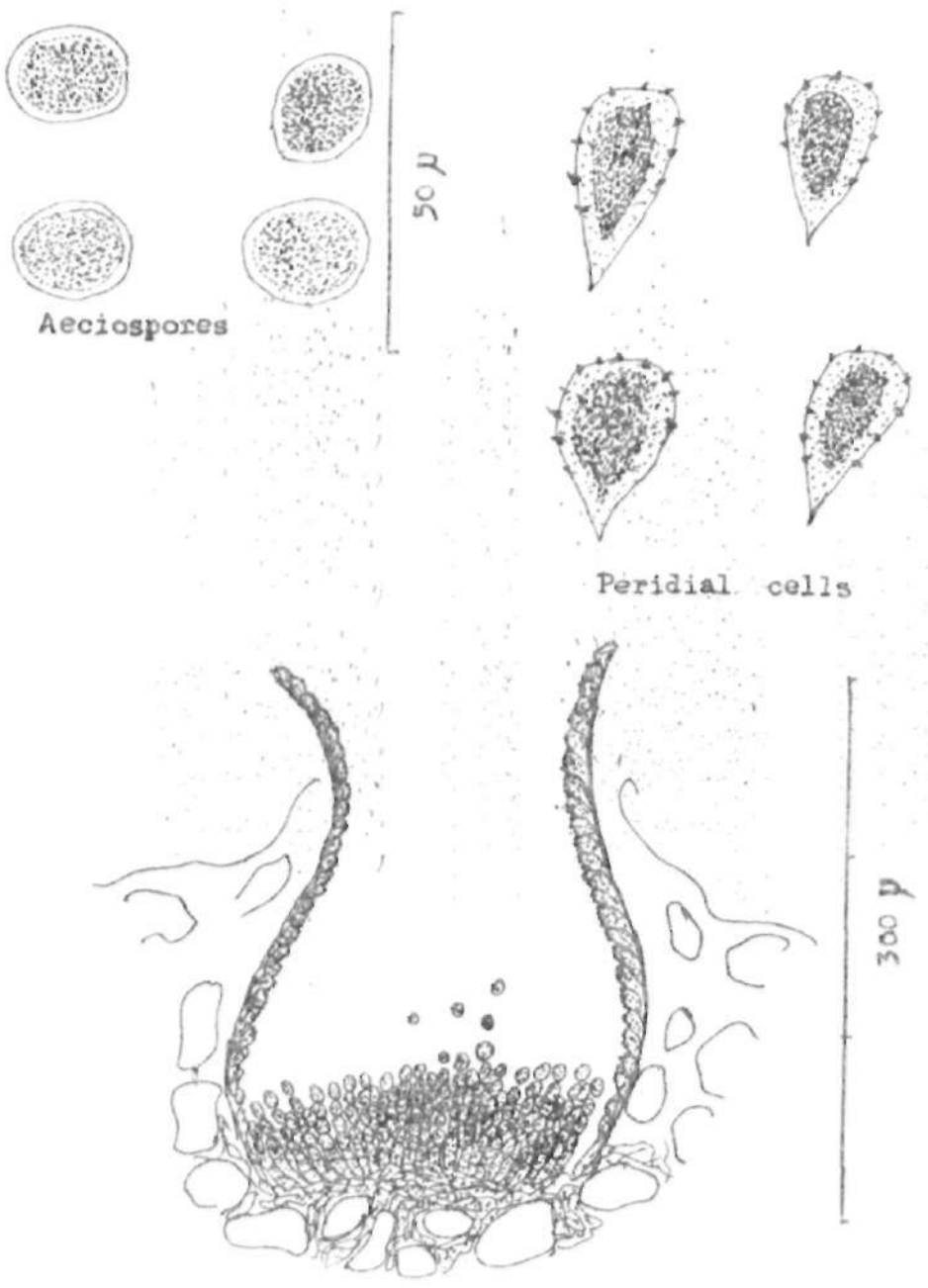


Fig. 18 AECIDIUM JASMINI ON JASMINUM DICHOTOMUM

19. PUCCINIA LEUCADIS Sydow

(Plate XIX ; Fig. 19)

Occurrence :

Leucas martinicensis L. is an annual weed commonly found in cultivated fields. The rust appeared in the month of September and continued till the host dried up. Both uredinia and telia formed simultaneously but uredinia were more prominent. There was no earlier record of this from Nigeria.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Rust spots numerous, amphigenous, circular, with diffused margin, yellowish on the upper surface initially, becoming brown later, spots on the stem and petiole irregular, deep brown; uredinia mostly hypophyllous, scattered, prominent, pulverulent, epidermis rupture early, spores spherical, to ovate, thin walled, wall brown, echinulate, thick walled spores rare, usually deeper in colour, germ pores 2, equatorial, 19.2 - 26.2 x 19.2 - 22.8 µ; aparaphysate.

Telia : Sori isolated, or mixed with uredinia, deep brown, epidermis rupture early; spores 2 - celled, lower cell longer than the upper one, cylindro-clavate, septum prominent, slightly constricted, wall smooth, uniformly thickened at sides up to 2 µ, apex rounded or slightly pointed, thickened up to 7.5 µ , contents cinnamon-brown in lower cell and dark dark brown in upper cell and intensifying towards the apex, 19 - 24 x 27 - 37 µ, pedicel short, light brown, wall

thickened up to 1.5 μ, up to 75 μ long, not collapsing.

Identification :

The rust under study closely resembles P. leucadis recorded on this host genus by Sydow. The characters of the rust under study are compared with the original description in Table 18.

Table 18. Details of Puccinia leucadis compared with the rust under study.

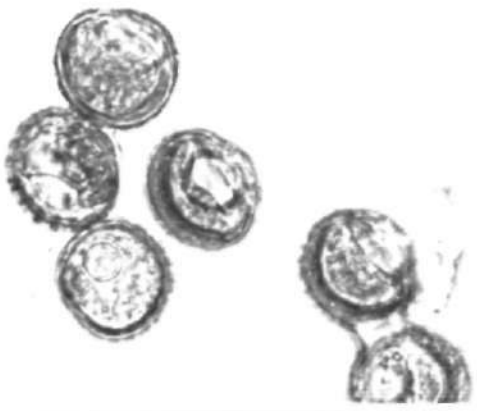
Rust species	Uredinia			Telia		
	Measurements (in μ)	P	G P	Measurements (in μ)	P	Apex (μ)
Puccinia leucadis	20.0 - 28.0 x 18.0 - 22.0	-	2 E	25.0 - 40.0 x 18.0 - 25.0	-	8.0
Rust under study	19.2 - 26.2 x 19.2 - 22.8	-	2 E	27 - 37 x 19 - 24	-	7.5

Sydow (1904) described the rust on Leucas martinicensis L. Tarr (1955) reported the same from Sudan on L. martinicensis. It has been also reported from India on the same host genus (Butler & Bisby, (1931)

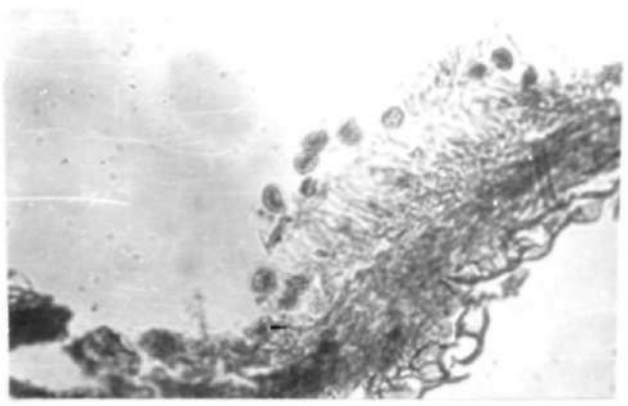
The specimens were collected on living leaves of Leucas martinicensis L. (Labiatae) from Zaria on October 20, 1982.



a. Infected plant



b. Urediniospores



c. Uredinium (section)



d. Teliospores

PLATE XIX. Puccinia leucadis on Leucas martinicensis

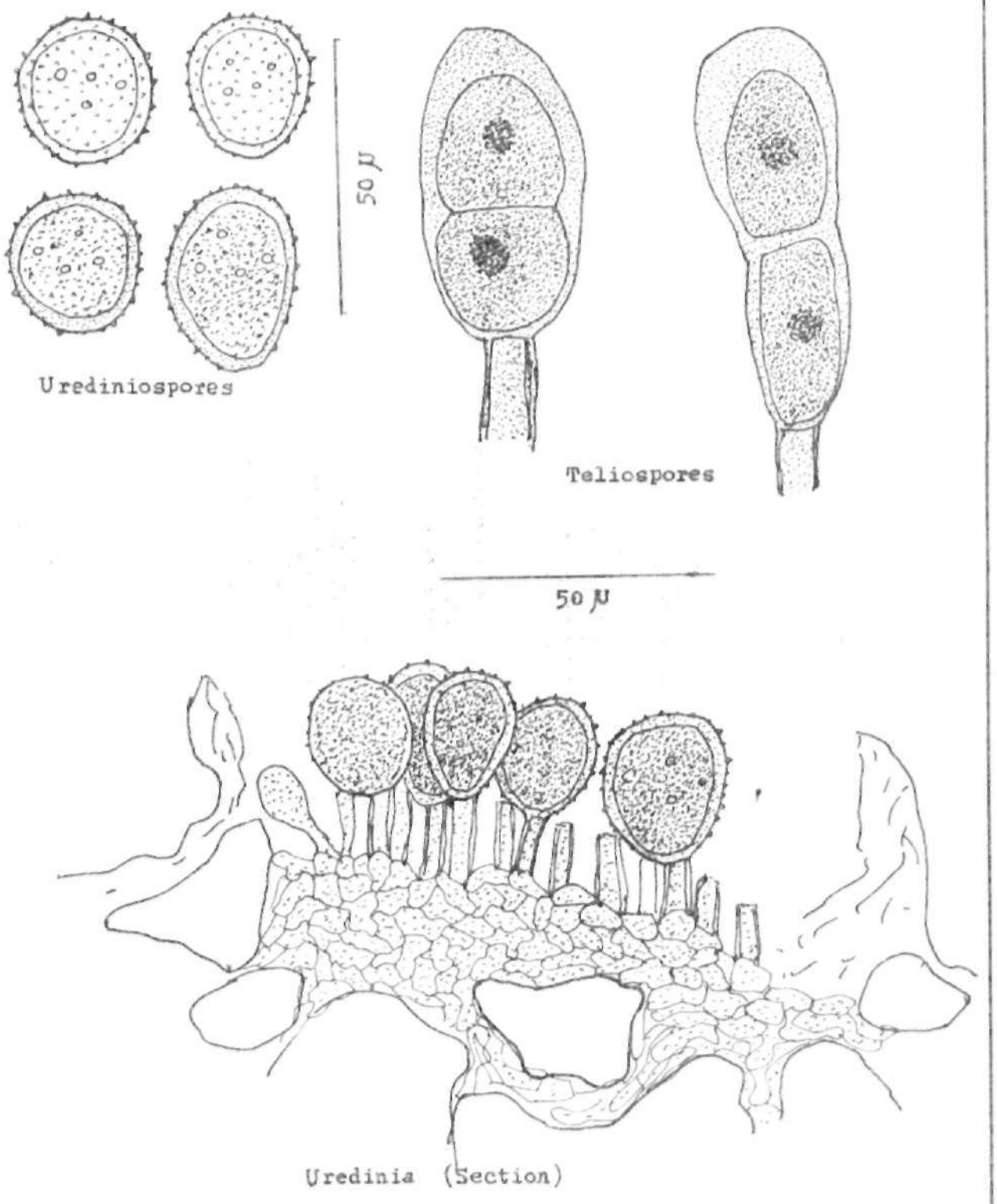


FIG. 19 PUCCINIA LEUCADIS ON LEUCAS MARTINICENSIS

20. PUCCINIA ARACHIDIS Spegazzini

(Plate XX & XXI ; Fig. 20)

Occurrence :

Groundnut or pea nut (Arachis hypogea L.) is a commercial oil yielding crop grown mostly in the northern parts of Nigeria. The rust occurs in its uredinial stage alone on this crop. The initial collection of this rust was made during August. The rust continues to infect the plant till harvest. It was also observed on the self sown plants in the green house area during the month of April, 1983. The occurrence of this rust is reported from several countries including the U.S.S.R. (1910), Mauritus (1914), Peoples Republic of China (1937) and from 1960 to date in many other countries in Asia, Australia and Oceania (Arthur, 1934; Subramaniam and McDonald, 1983). In Nigeria, it was first reported in 1975 (Arokoyo et al., 1977).

Description :

Pycnia and aecia : Not observed durirg the studies.

Uredinia : Rust spots yellowish becoming brown, round, scattered; sori mostly hypophyllous, isolated in the beginning but become aggregate, formed on petioles, stem and bracteoles, erumpent; spores oblong or obovate, wall thin up to 2 µ, brown, finely echinulate, germ pores 2, equatorial, rarely 3 - 4; parapysate, paraphyses clavate, thin walled. 21.6 - 26.4 x 16.8 x 21.6 µ.

Telia : Telia were not observed from the specimens collected from Nigeria. It is also seen from the literature that

it is not observed in any other country on groundnut. It was originally recorded on Arachis glabrata collected from Campogrande, Brazil by Archer in 1936. During the studies, the specimens bearing telia were received from the U.S.D.A. National Herbarium, Beltsville, The description given below is based on the examination of the above.

Telia mixed with uredinia, hypophyllous, dark brown, crumpent, epidermis rupture early; spores 2 - celled, oblong or obovate or ellipsoid with obtuse apex, wall uniformly thickened at sides up to 1.5 µ, light yellow, apex thickened up to 5 µ, prominently constricted at the septum, attenuate towards the base, sometimes having angular surface due to the compactness of the spore arrangement inside the pustule, contents chestnut-brown, 35.2 - 43.6 x 14.6 - 17.0 µ; pedicel thin walled, hyaline, up to 65 µ long, not collapsing.

Identification :

The rust in its uredinial stage closely resembles the specimens received from the U.S.D.A.National Herbarium and also the earlier descriptions published by Spegazzini (1884) and therefore identified Puccinia arachidis. Cummins (1978) listed the following as the synonyms to Puccinia arachidis :

Uredo arachidis Lagerheim

Uromyces arachidis P. Hennings

Bullaria (?) arachidis (Speg.) Arthur and Mains

Bromfield (1971) published the review of literature of this rust.

Germination :

The urediniospores when floated on sterile distilled water, readily germinated within 3 hours. A single germ tube comes out through one of the germ pores. The germ tube is short and the contents of the spore flow towards the growing tip. When the spores were allowed for a longer period to remain floated on the water, the germ tubes become longer, curved and irregular.

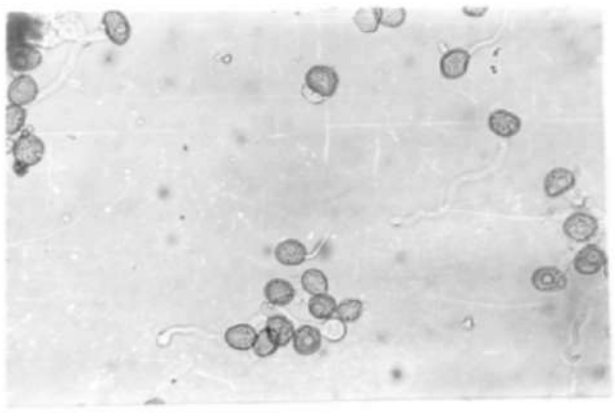
The specimens were collected on living leaves of Arachis hypogea L. (Leguminosae) from Zaria on September 10, 1982.



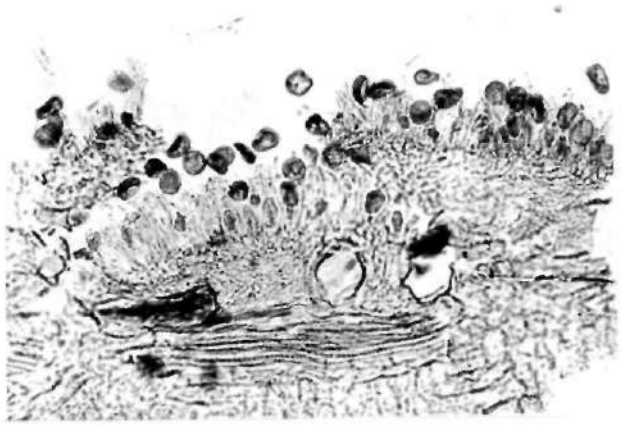
a. Infected plant



b. Urediniospores



c. Urediniospores (germination)

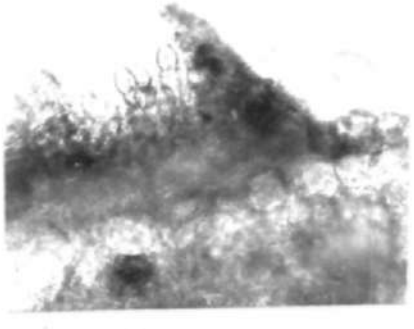


d. Uredinium (section)

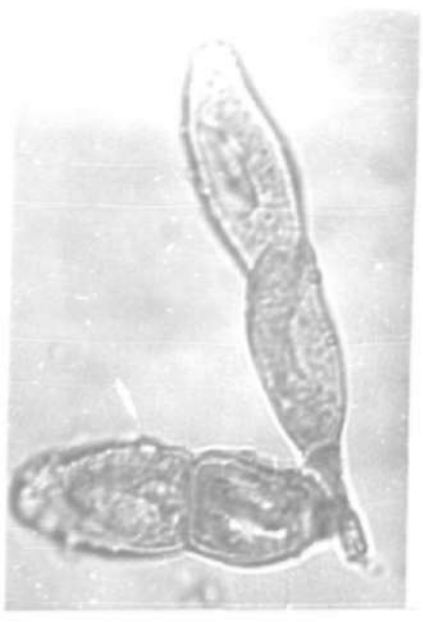
PLATE XX. Puccinia arachidis on Arachis hypogea (Zaria collection)



a. Urediniospores (Type)



b. Telium (section from Type)



c. Teliospores (Type)

PLATE XXI. Puccinia arachidis on Arachis glabrata (Type)

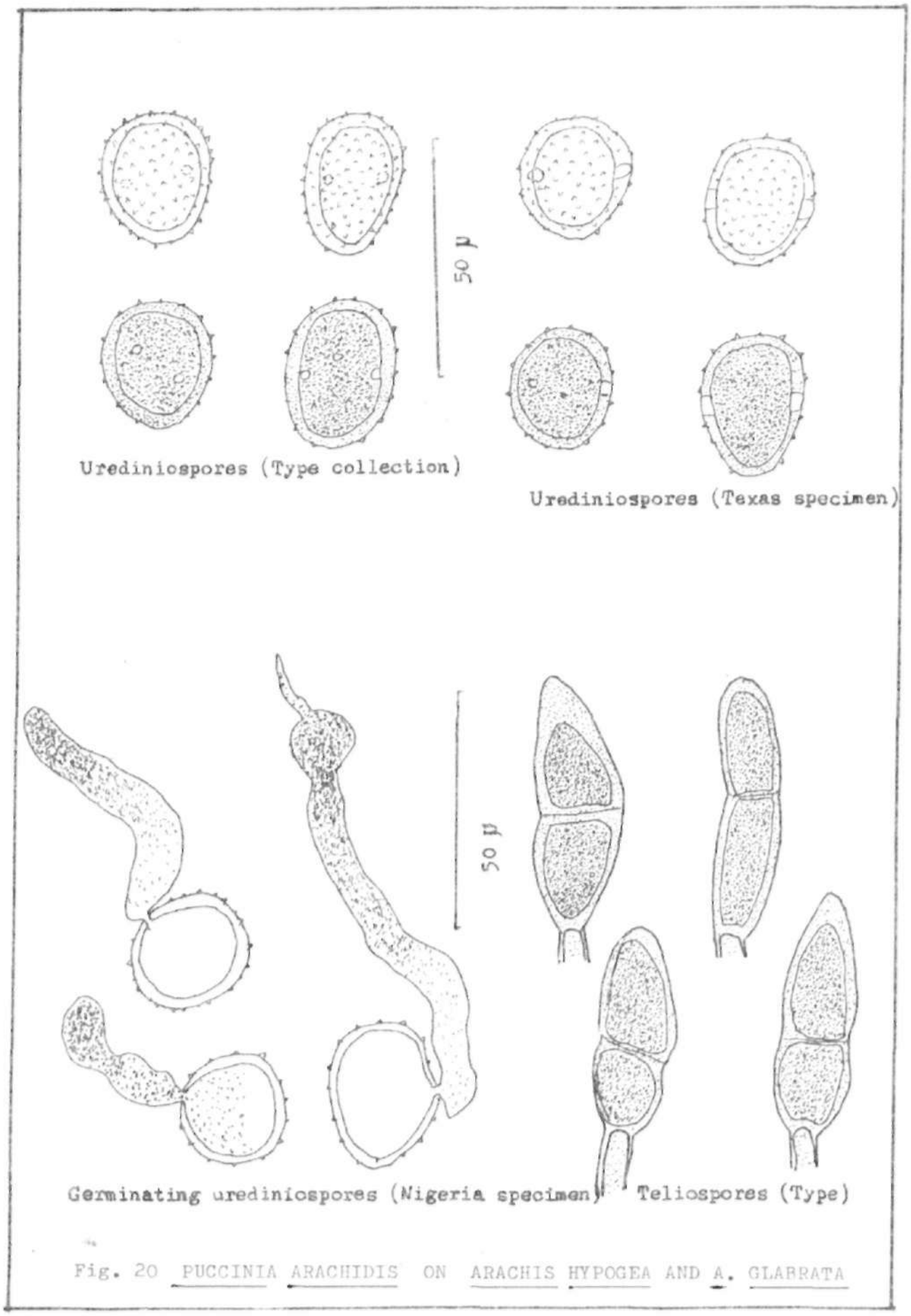


Fig. 20 PUCCINIA ARACHIDIS ON ARACHIS HYPOGEA AND A. GLABRATA

21. RAVENELIA Species nova

(Plate XXII ; Fig. 21)

Occurrence :

The host Albizzia chevalieri Durazz. is a perennial evergreen tree growing in forest and abandoned areas. The rust was collected on this host in Zaria throughout the year. The uredinial stage was more prominent during June to October and later the telia almost replaced the uredinia. There is no record of this rust from Nigeria or other countries.

Description :

Uredinia : Spots prominent, epiphyllous, light yellow, numerous; uredinia mostly epiphyllous, formed in circles, epidermis rupture widely, formed also on petioles and young stem; spores ovoid, oblong, wall thickened up to 1 μ at base and progressively increasing towards the apex up to 4.5 μ, germ pores 4, very prominent, equatorial, wall coloured, surface strongly echinulate, contents light cinnamon-brown at base becoming deeper towards the apex, acuminate tip, with a distinct papilla in most of the spores, 24 - 36 x 15 - 24 μ; aparaphysate.

Telia : Sori isolated, in groups or mixed with uredinia, epiphyllous, erumpent, epidermis exposed, shining black; teliospores 1 - celled, strongly united laterally forming pedicellate, discoid heads of spores, surrounded by hygroscopic cysts, one for each basal spore; pedicel composed of several hyphoid strands strongly adhering to form a fascicle,

one germ pore in each cell, surface sparsely covered with echinulate spines; immature telial heads yellowish-brown, matured become dark brown; telial heads measure 72 - 96 x 58 - 91 μ, containing 4 - 6 spores in vertical composition, single spore 22.4 - 26.4 x 19.2 - 22.4 μ; aparaphysate.

Identification :

Four species of Ravenelia have been recorded on the host genus so far from different countries, the details of which are given in Table 19.

Table 19. Details of Ravenelia species recorded on the genus Albizzia and the rust under study

Rust species	Uredinia			Telia		
	Measurements (in μ)	P	GP	Measurements (in μ) Head	Single	Thick@ of head
Ravenelia japonica Diet.& Syd.	17 - 23 x 15 - 18	-	-	N A	15 - 25	6 - 8
R. clemense Syd.	22 - 34 x 17 - 22	-	4 E	70 - 110	22 - 26	4 - 6
R. minima Cke.	22 - 35 x 14 - 21	-	4 E	50 - 65	19 - 25	4 - 7
Rust under study	24 - 36 x 15 - 24	-	4 E	72 - 96 x 58 - 91	22 - 26 x 19 - 24	4 - 6

@ Thickness

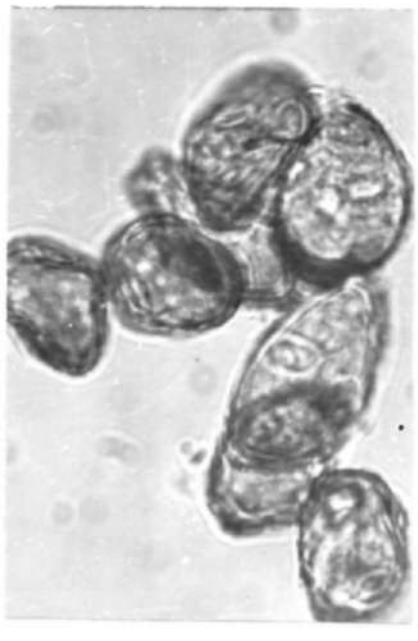
The morphological characters and spore measurements of the rust under study vary from other reported species. It differ's from the rest of the recorded species in having larger urediniospores with conspicuous thickening at the apex and having darker colour towards the apex. The germ pores are very prominent in the rust under study. Individual teliospores are larger than the previously recorded ones. The telial heads are larger, the ornamentation on the teliospores are more prominent, telial heads darker in colour than others.

Mrs. Mardue (personal communication) of the Commonwealth Mycological Institute, London confirms after comparing the Ravenelia species recorded on the host genus that the rust on Albizzia chevalieri differs from other recorded ones and considers it as a new species.

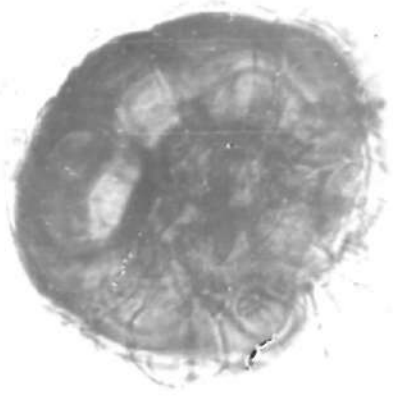
The specimens were collected on living leaves of Albizzia chevalieri Durazz. (Mimosoideae) on October 20, 1982 from Zaria. I M I No. 285926.



a. Infected leaflets

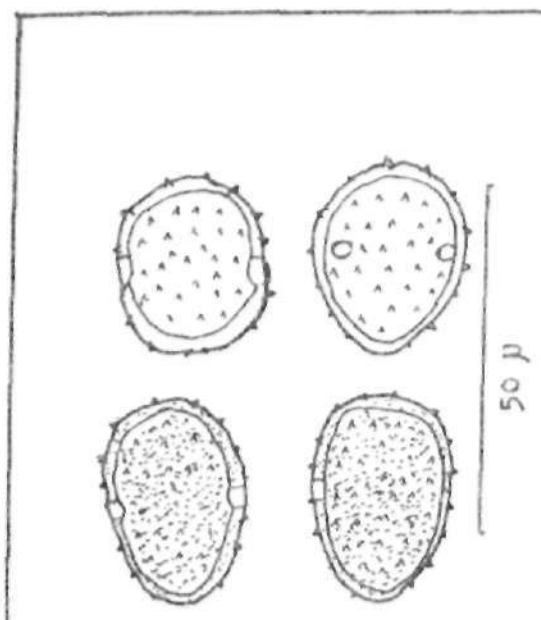


b. Urediniospores

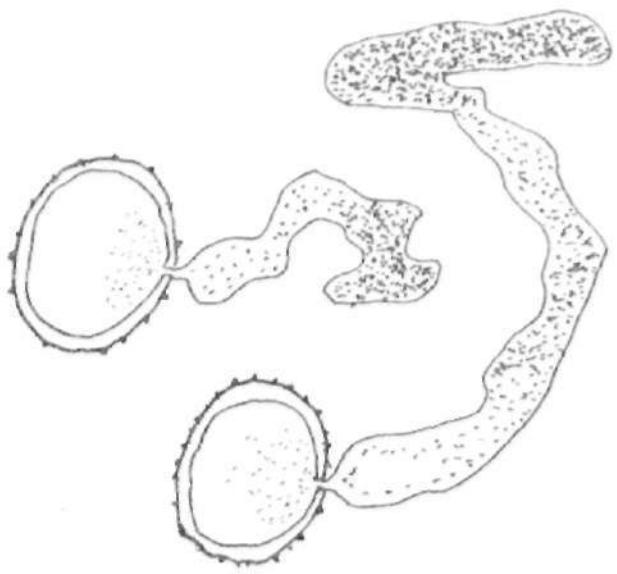


c. Telial head

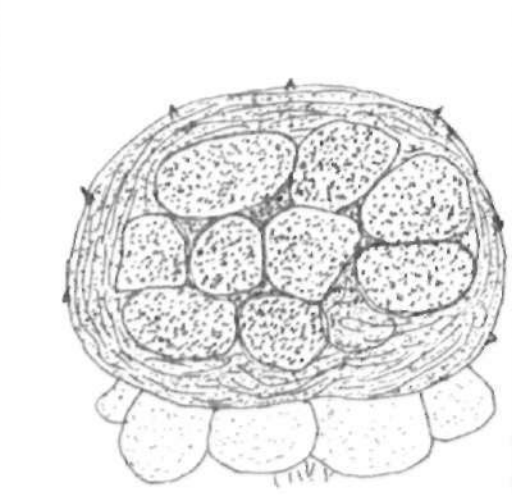
PLATE XXII. Ravenelia species nov. on Albizzia chevalieri



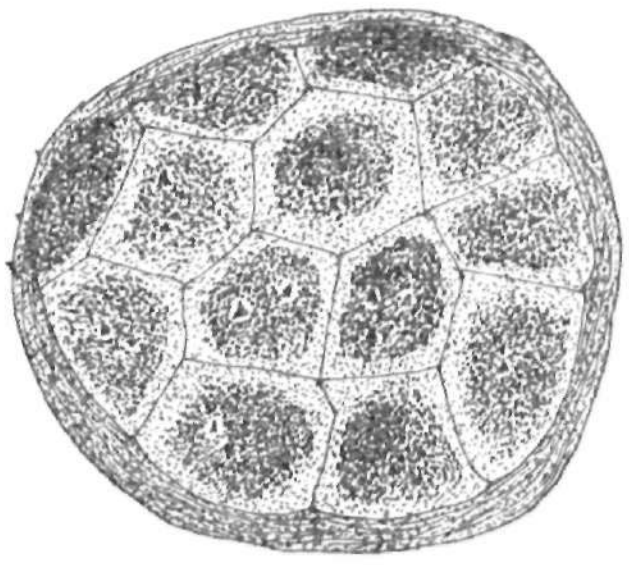
Urediniospores



Urediniospores (Germination)



(Telial head vertical view)



(Telial head surface view)

Fig. 21 RAVENELIA SPECIES NOVA ON ALBIZZIA CHEVALIERI

22. UROMYCES OCCIDENTALIS Dietel

(Plate XXIII ; Fig. 22 a)

Occurrence :

The host Crotalaria retusa L. is a very common weed found throughout Nigeria. It remains green for most part of the year in and around Zaria. The rust appears from August onwards and continues up to the end of January. Eboh (1978) recorded the same rust on Crotalaria retusa from Nsukka (Nigeria).

Description :

Pycnia and aecia : Not observed during the study.

Uredinia : Rust spots yellowish, round becoming dark brown at maturity; sori epiphyllous, isolated to start with, finally surrounded by many sori formed in circles, erumpent, epidermis rupture exposing the spore mass; spores spherical to obovoid, sometimes elongate, wall uniformly thick up to 2 µ, brown, finely echinulate, contents yellowish-brown, germ pores 4, equatorial, 16.8 - 24.0 x 16.8 - 19.2 µ; aparaphysate.

Telia : Sori isolated or mixed with uredinia, dark brown, erumpent, epidermis rupture early; spores 1 - celled, wall uniformly thickened up to 2.5 µ at sides and 48 µ at apex, brown, obovate to oblong, finely echinulate, spines forming longitudinal lines or fused to form ridges, contents golden yellow to chestnut- brown, a small pale umbo over the pore at apex, 18 - 25 x 16 - 19µ; pedicel break close to the base.

Identification :

Two species of Uromyces have been recorded earlier on the host genus. The details of the spore measurements and the characters of them along with the rust under study are given in Table 20.

Table 20. Details of Uromyces species recorded on Crotalaria species

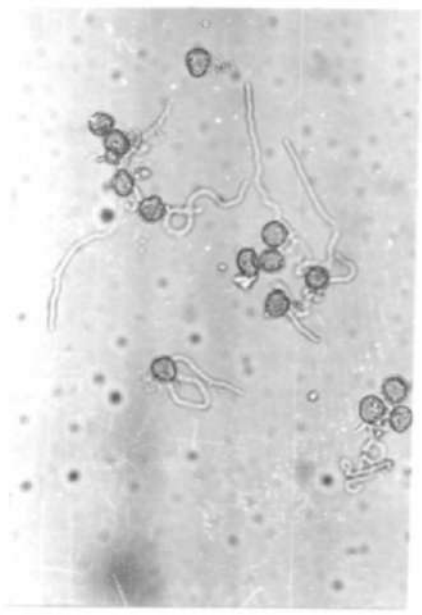
	Uredinia			Telia	
	Measurement (in µ)	P	G P	Measurement (in µ)	P
Uromyces crotalariae	24 - 28 x	-	6 - 8	27 - 32 x	-
Arthur	20 - 25		S	20 - 27	
U. occidentalis Diet.	20 - 27 x	-	7 - 9	17 - 28 x	-
	16 - 23		S	14 - 28	
Rust under study	17 - 24	-	6 S	18 - 25 x	-
	16 - 19			16 19	

The rust under study closely resembles Uromyces occidentalis in spore characters and measurements and is therefore identified as such. The first record of this rust was made by Dietel (1903) on Lupinus latifolius J. Agon. collected from Sissons, California. The accial stage was recorded by Cummins (1978) occurring on Euphorbia (Tithymalus).

The specimens were collected on living leaves of Crotalaria retusa L. (Leguminosae) from Zaria on November 11, 1982.



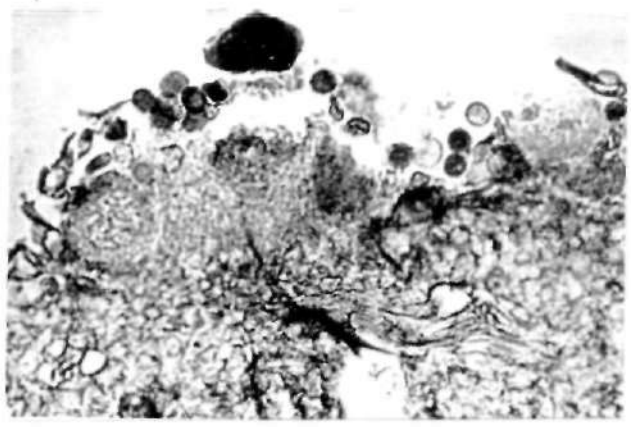
a. Infected plant



b. Urediniospores (germination)



c. Urediniospores and Teliospores



d. Uredinium parasitised by Darluca filum (section)

PLATE XXIII. Uromyces occidentalis on Crotalaria retusa

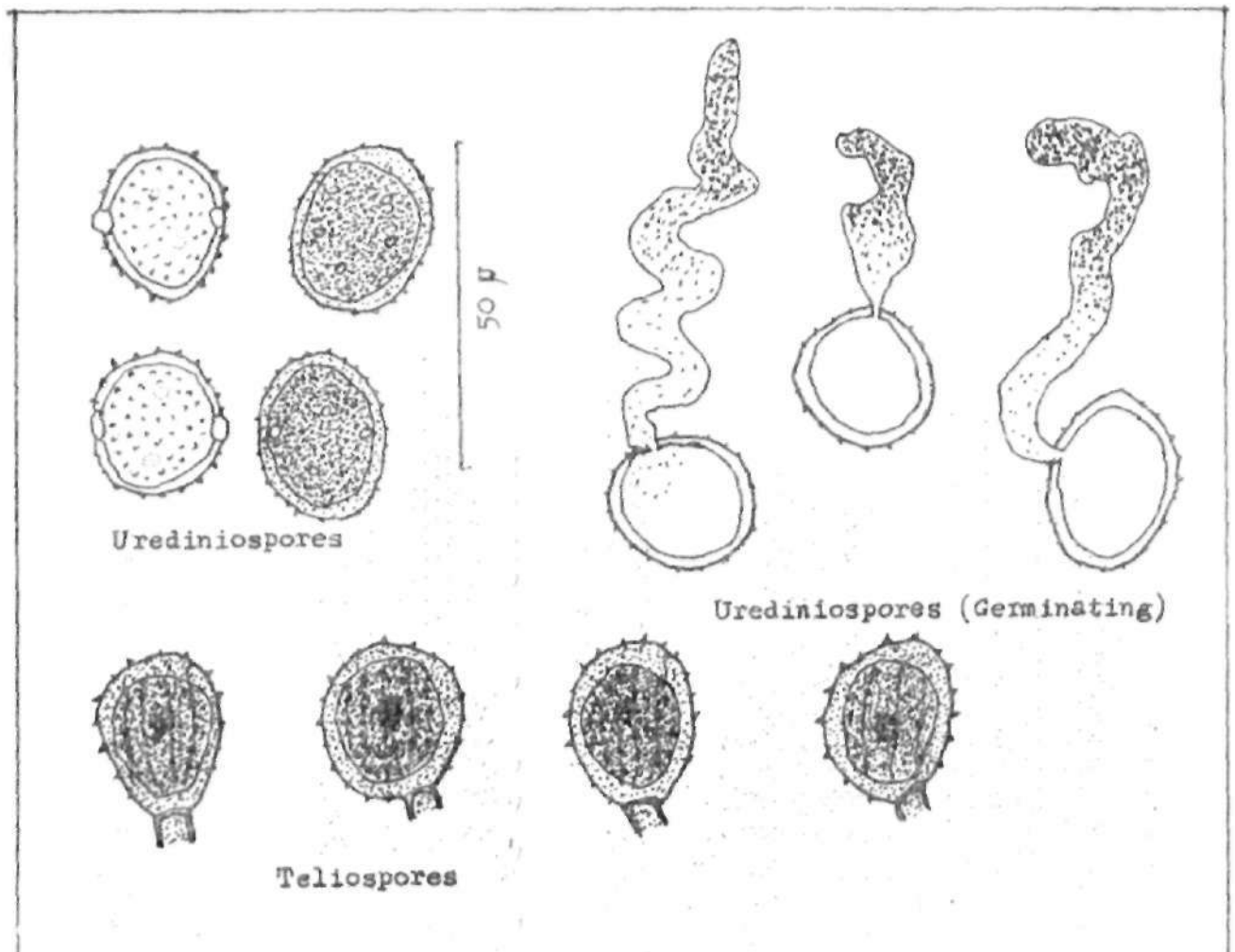


Fig. 22 A UROMYCES OCCIDENTALIS ON CROTALARIA RETUSA

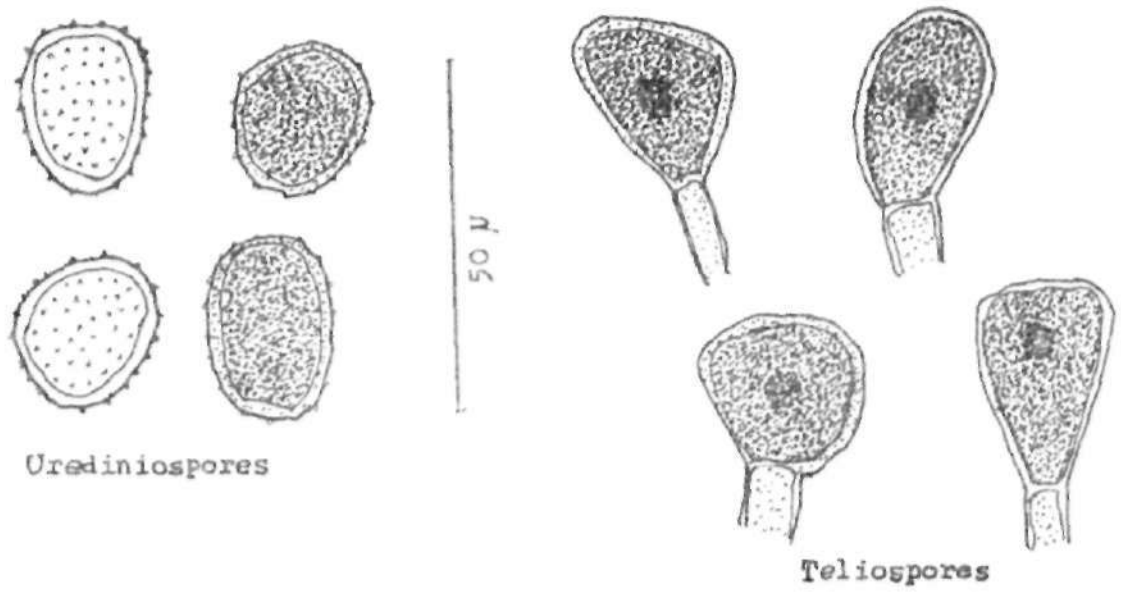


Fig. 22 B UROMYCES SPECIES NOVA ON ALBUCA SUDANICA

23. RAVENELIA Species nova

(Plate XXIV ; Fig. 23)

Occurrence :

The host Tephrosia bracteolata Pers. is a common weed found on waste lands in and around Zaria. It has a wide distribution in Nigeria. The rust under study occurs from July through November. In the early months, the uredinia were more prominent, later telia over grew uredinia. There is no record of any rust on the host from Nigeria.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Spots minute, inconspicuous, mostly hypophyllous; uredinia amphigenous, small, isolated, subepidermal, erumpent, epidermis rupture early exposing the spores; spores ovoid to subglobose, hyaline to light yellow, densely echinulate, wall thickened up to 2 μ at sides and up to 4 μ at apex, germ pores 5 - 6, obscure, scattered, 16.8 - 21.6 x 14.4 - 16.8 μ; aparaphysate,

Telia : Sori isolated or formed on older uredinia, epidermis rupture early; telial heads numerous, blackish; spores in compound fascicle, 3 - 4 spore depth, strongly united laterally and at base forming a discoid head of several hyphal strands appearing as single pedicel at the bottom of the spores; cysts one each to the corresponding number of basal cells, surrounding the pedicel, hygroscopic, hyaline; teliospores irregular in shape, thickened at the apex, strong prominent

spines on free surface, contents cinnamon-brown, wall highly pigmented, 1 - celled, 21.6 p 26.4 x 14.5 - 19.2 μ; the compound head measure 50 -50 μ.

Identification :

Five species of Ravenelia have been recorded on the host genus Tephrosia from different parts of the world in the past. The details of the rusts recorded and the rust under study are given in Table 21.

Table 21. Spore mesurements of Ravenelia species recorded on the genus Tephrosia and the rust under study.

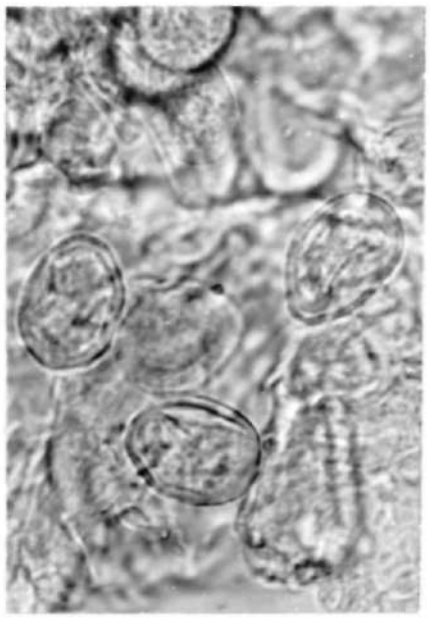
Rust species	Uredinia			Telia		
	Measurements (in μ)	P	G P	Measurements (in μ) Head	Single spore	Thickness of head
Ravenelia talpa	21 - 25 x	+	4 - 6	69 - 95	21 - 27	4 - 6
Arthur	17 - 20		E			
R. caulicola	19 - 23 x	+	8	75 - 105	17 - 22	5 - 7
Arthur	14 - 16		S			
R. irregularis	20 - 22 x	+	8	60 - 90	16 - 20	4 - 6
Arthur	17 - 19		S			
R. epiphylla	27 - 33 x	+	5 -7	80 - 125	18 - 24	5 - 8
(Schw.) Diet.	19 - 22		E			
R. tephrosiae	24 - 30 x	-	8	80 - 150	18 - 30	6 - 8
Kalchbr.	20 - 25		E			
Rust under study	17 - 22 x	+	5 6	70 - 110	22 - 26	3 - 4
	14 - 17					

The rust under study differs from all other species recorded earlier on the host genus Tephrosia in the following characters namely, the absence of pycnia and aecia, the shape of urediniospores, colour of wall and the contents of the spore. The germ pores are not prominent in the rust under study unlike they are in others. The teliospore size is larger in the rust under study. It is also different from Ravenelia talpa recorded on the host genus from Nsukka by Eboh (1978) in the absence of aecia, smaller urediniospores, obscure germ pores and 3 - 4 teliospore rows as compared to 4 - 6 in R. talpa. It is therefore considered to be a new species. The identification as a new species was also confirmed by Mrs. Mardue of Commonwealth Mycological Institute, London who examined the specimens.

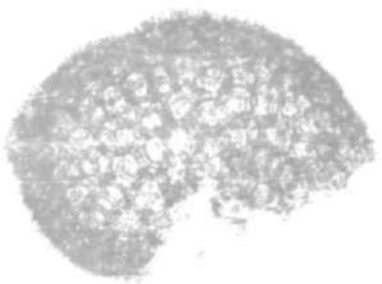
The specimens were collected on living leaves of Tephrosia bracteolata Pers. (Leguminosae) from Zaria on October 15, 1982. I M I No. 285921.



a. Infected leaflets

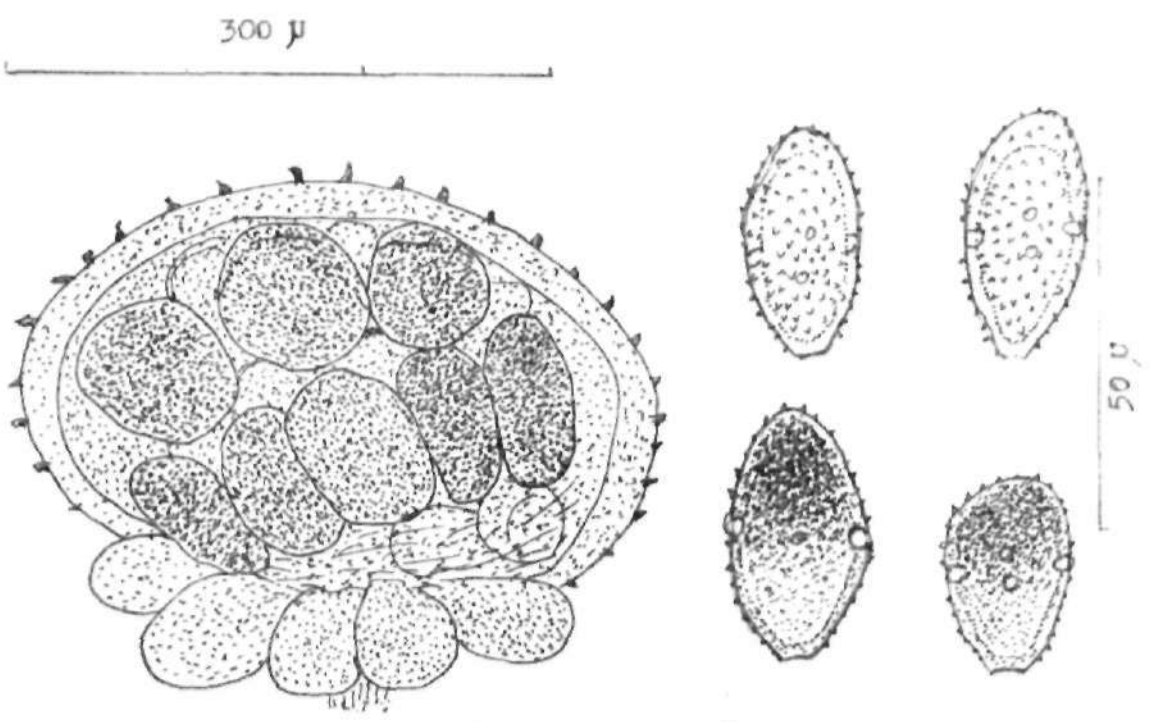


b. Urediniospores

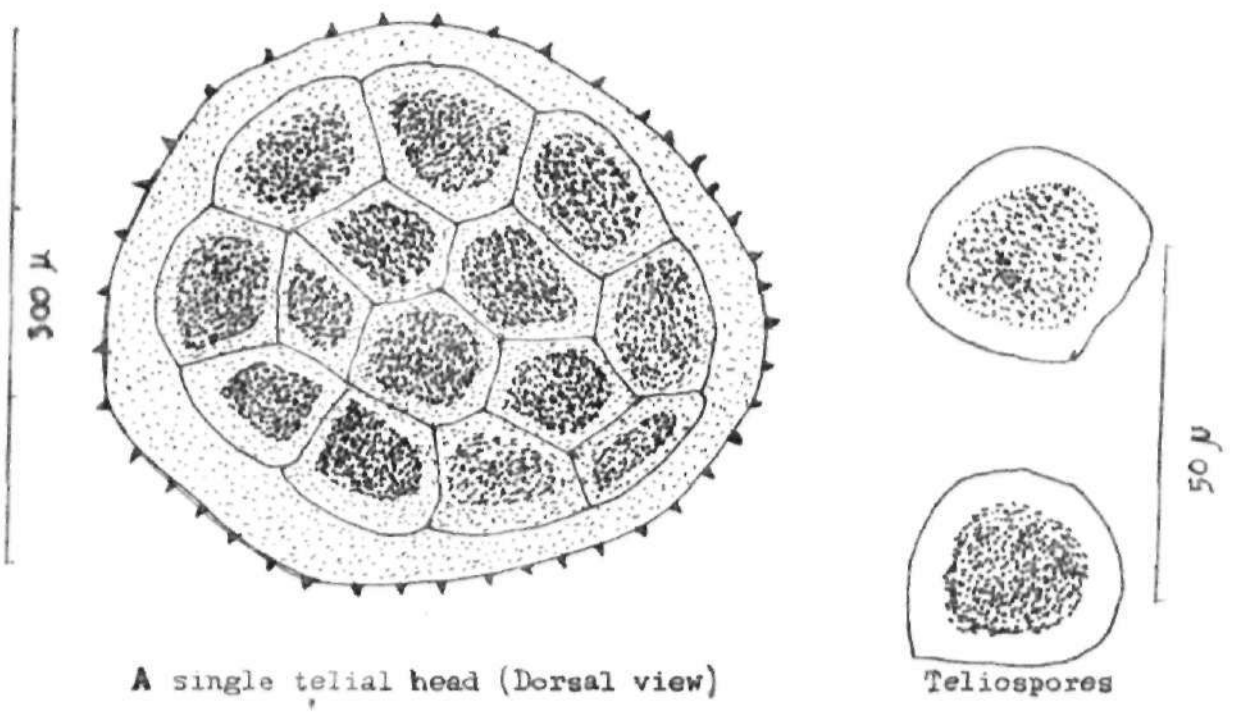


c. Telial head

PLATE XXIV. Ravenelia species nov. on Tephrosia bracteola



A single telial head (Sectional view) Teliospores



A single telial head (Dorsal view) Teliospores

Fig. 23 RAVENELIA SPECIES NOVA ON TEPHROSIA BRACTEOLATA

24. UROMYCES APPENDICULATUS (Pers.) Unger var. appendiculatus

(Plate XXV ; Fig. 24)

Occurrence :

Cowpea (Vigna unguiculata (L.) Walp.) is the principal crop grown in Nigeria. This crop is infected by the rust disease almost every year. It appears on the crop by the end of August in its urdinial form. The telia invariably appear in October and continue till the harvest of the crop in November - December. Besides on Vigna, it has been recorded on species of Phaseolus and Strophotyles in many parts of the world (Cummins, 1978). Eboh (1978) recorded Aecidium caulicola P. Henn. on this host from Nsukka. In Nigeria, the rust occurs on Vigna unguiculata in many localities (Emechebe, et al., 1980).

Description :

Pycnia and necia : Not observed during the studies.

Uredinia : Spots amphigenous, prominent, light brown; uredinia scattered, amphigenous but mostly epiphyllous, epidermis rupture; spores obovate to ovate, wall uniformly thickened up to 3 µ, light brown, finely verrucose, contents golden yellow, pores 3, obscure, equatorial, 21.6 - 29.0 x 16.8 - 24.0 µ; aparaphysate.

Telia : Sori isolated or mixed with uredinia, erumpent, dark brown to blackish, epidermis rupture early; spores 1 - celled, spherical to broadly ellipsoid, with prominent umbo, pale and defined, wall uniformly thick up to 5 µ at sides and 10 µ

at apex, wall darker in colour than the contents; pedicel short up to 35 µ, thin walled, collapsing, hyaline to light yellow; aparaphysate.

Identification : Two species including two varieties of Uromyces have been recorded on the host genus, the details of which are given in Table 22.

Table 22. Details of Uromyces recorded on Vigna unguiculata and the rust under study.

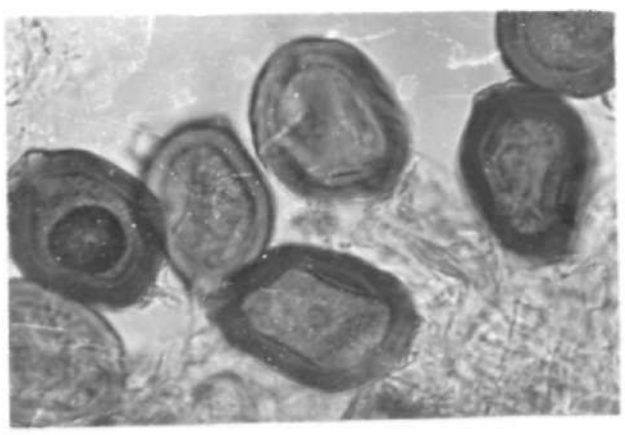
Rust species	Uredinia			Telia		
	Measurement (in µ)	P	G P	Measuremenrs (in µ)	P	Apex (µ)
Uromyces vignae Baul.	25 - 30 x 23 - 28	-	2 near apex	30 - 38 x 19 - 24	-	4.8
U. appendiculatus var. appendiculatus Unger	24 - 30 x 20 - 27	-	2 E	28 - 33 x 22 - 27	-	11.0
U. appendiculatus var. punctiformis (P.Syd.) Cummins	24 - 26 x 19 - 21	-	0	35 - 40 x 28 - 31	-	No record
Rust under study	22 - 27 x 17 - 24	-	2 E	26 - 36 x 19 - 29	-	10.0

The rust under study very closely resembles Uromyces appendiculatus var. appendiculatus recorded on this host. The first record of this rust was made by Persoon (1801) who named it Uredo appendiculatus and Uredo phaseoli. Unger (1836) revised the nomenclature of it and named it Uromyces appendiculatus var. appendiculatus (Cummins, 1978).

The specimens were collected on living leaves of Vigna unguiculata (L.) Walp. (Leguminosae) from Zaria on November 6, 1982.



a. Infected leaves

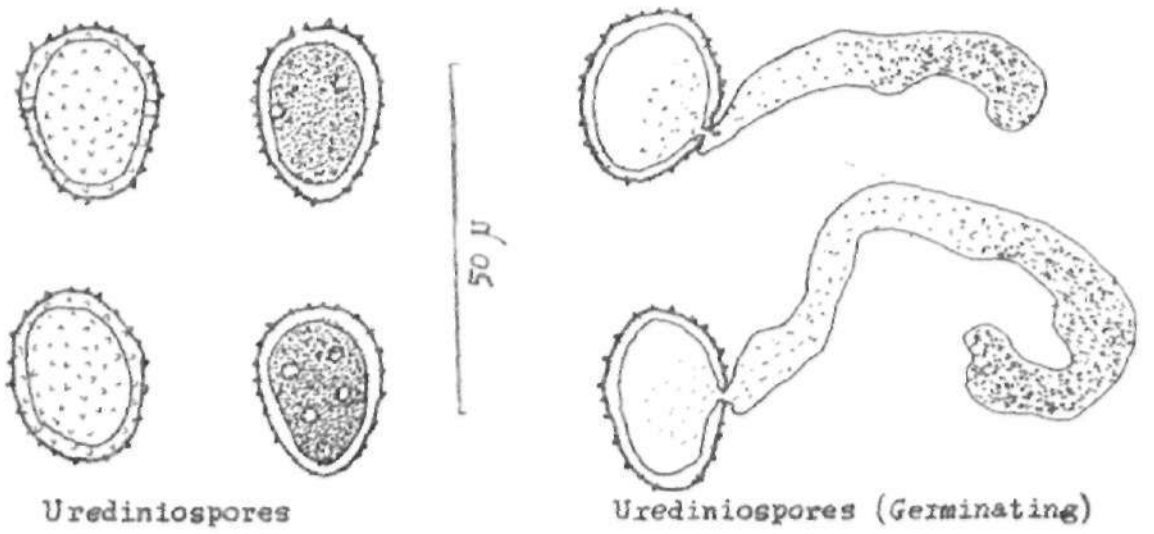


b. Urediniospores



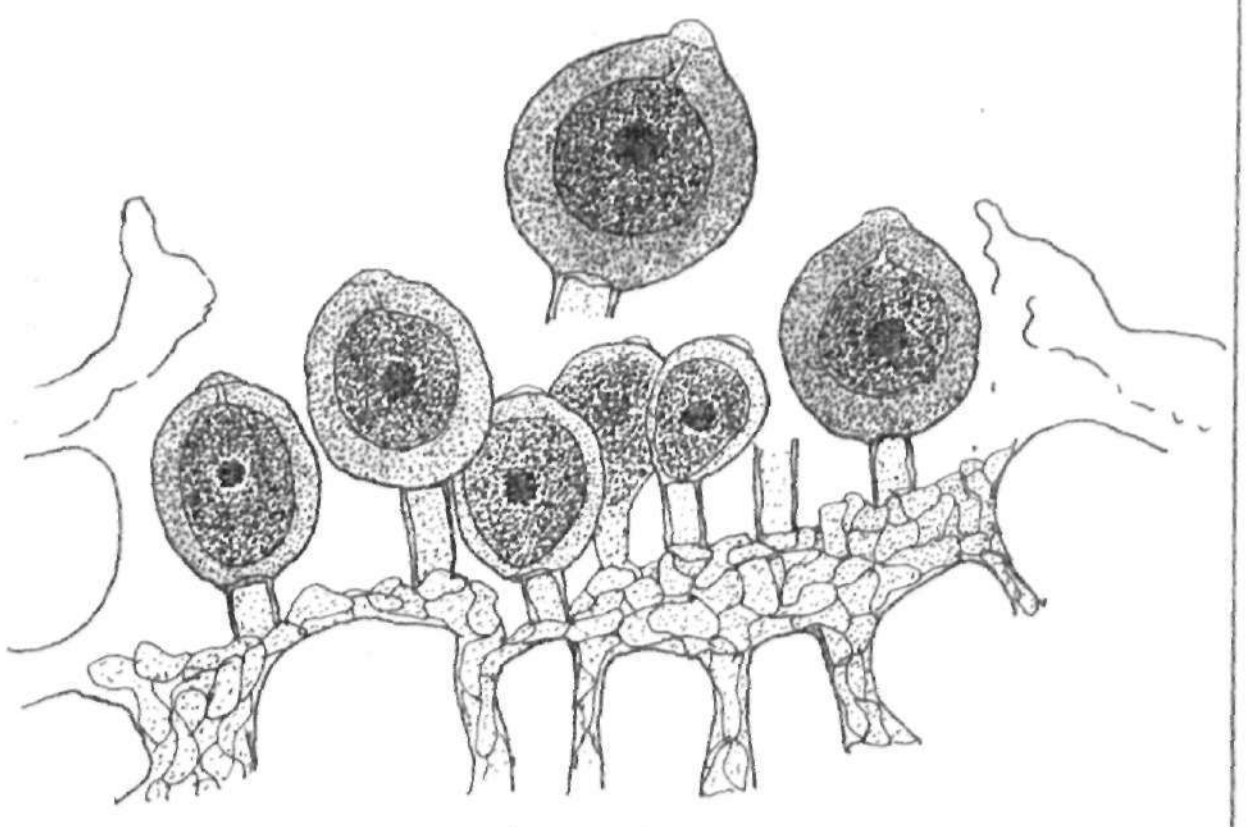
c. Teliospores

PLATE XXV. Uromyces appendiculatus var. appendiculatus on Vigna unguiculata



Urediniospores

Urediniospores (Germinating)



Telium (Section)

Fig.24. UROMYCES APPENDICULATUS VAR APPENDICULATUS ON VIGNA UNGUICULATA

25. UROMYCES Species nova

(Plate XXVI ; Fig. 22b)

Occurrence :

The host Albuca sudanica A.Chev. is a perennial weed having underground bulb to survive the dry summer period. The green foliage appears soon after the onset of the rainy season. However, the first appearance of the rust was noticed during August. Uredinia were the first to appear followed by telia in about a month later. Fresh infection continues to appear till the host remains green. From the available literature it is seen that no record of any Uromyces species was made earlier either from Nigeria or other countries.

Description :

Pycnia and aecia : Not observed during the studies.

Uredinia : Spots prominent, amphigenous, bright orange, turn brown at maturity, large; uredinia amphigenous, isolated or in groups, deep seated in origin, epidermis mostly covered except a slit-like opening; spores ovate to ellipsoid, wall uniformly thick up to 1.5 µ, echinulate, contents light yellow, germ pores 2, prominent, hilum prominent, 19.2 - 24 x 14.4 - 19.2 µ; aparaphysate.

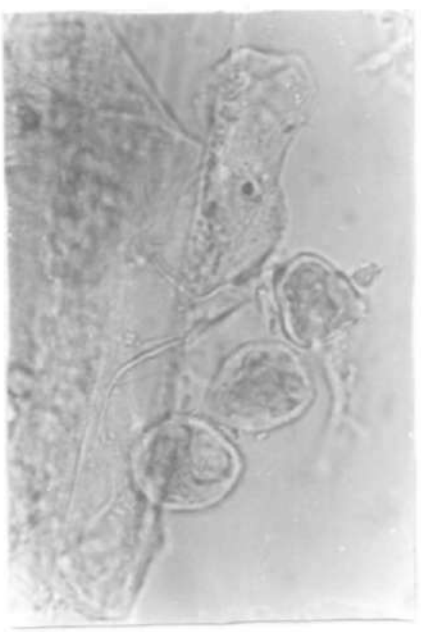
Telia : Abundant, isolated or mixed with uredinia, dark brown to blackish, covered by epidermis, erumpent; spores obovate to ovate, smooth surfaced, contents cinnamon-brown, wall thin up to 2 µ, 24.0 - 31.2 x 18.6 - 26.2 µ; pedicel thin walled, light brown, up to 55 µ long, not collapsing.

Identification : There is no previous record of rusts recorded on this host or allied ones and therefore it is identified as a new species.

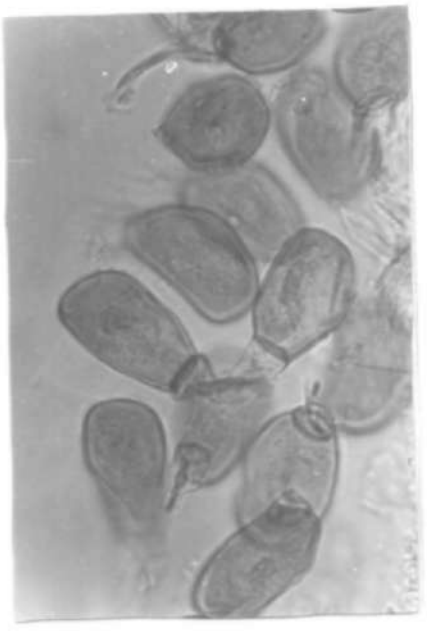
The specimens were collected on living leaves of Albuca sudanica A. Chev. (Liliaceae) from Zaria on November 19, 1982. IMI No. 285919.



a. Infected leaves



b. Urediniospores



c. Teliospores

PLATE XXVI. Uromyces species nov. on Albuca sudanica

26. AECIDIUM HARTWEGIAE Thuemen

(Plate XXVII ; Fig. 25)

Occurrence :

Chlorophytum stenopetalum Buk. is an ornamental plant growing under shady cool localities with lot of leaf mould. It is perennial in nature but under Zaria conditions it dries up during the dry season. New foliage appears soon after the onset of the wet season in June. The rust starts appearing from the end of August and continues for as long as the host remains green. There was no previous record of this rust from Nigeria.

Description :

Pycnia and aecia : Rust spots prominent, yellow, cover one quarter to half of the leaf breadth when fully formed; pycnia epiphyllous, dark brown, in groups, erumpent, sub-epidermal in origin, spherical, light brown, narrow opening with marginal flexuous hyphae; pycniospores minute, oval, borne on long thin stalks and exuded through the ostiole mixed with honey-like liquid, 80 - 96 µ in diam.; aecia cupulate, surrounded by lacerated white peridium; aeciospores bright yellow, ovate, to spherical with slightly angular sides, produced in chains on short hyaline stalks, thin walled, surface minutely verrucose, 19.2 - 31.6 x 14.0 - 20.0 µ; peridial cells hyaline, polygonal to sub-rhomboid, prominently echinulate on the free surface.

Aecidium hartwegiae was first recorded by Theumen (1878) based on the specimens collected from Central and East Africa.

The measurements of the spores as given in the original description are compared with the rust under study and the details are given in Table 23.

Table 23. Comparative measurements of Aecidium hartwegiae and the rust under study

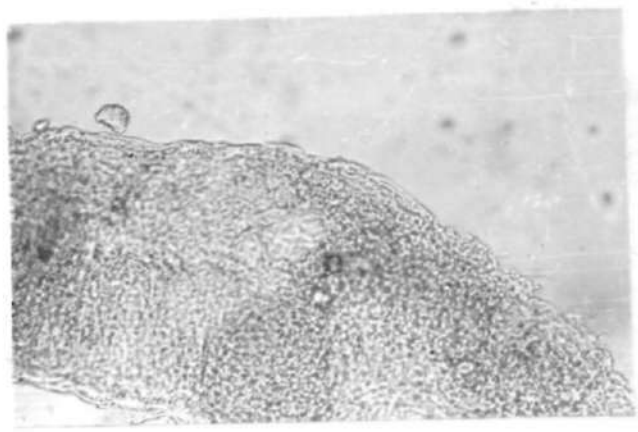
Rust species	Pycnia	Aecia		
	Measurement (in μ)	Measurements (in μ)		
		Aecial cups	Aeciospores	Peridial cells
Aecidium hartwegiae	100 - 150	250 - 300	20 - 25 x 17 - 20	25 - 35 x 17 - 24
Rust under study	80 - 96 x	220 - 320	19 - 32 x 15 - 21	25 - 38 16 - 26

The rust collected from Zaria closely resembles the Aecidium hartwegiae in spore characters and measurements and it is therefore identified as such.

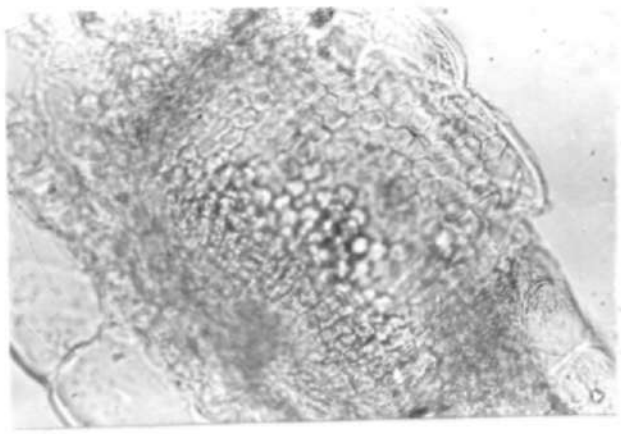
The specimens were collected on living leaves of Chlorophytum stenopetalum Buk. (Liliaceae) from Zaria on August 16, 1982. IMI No. 285922.



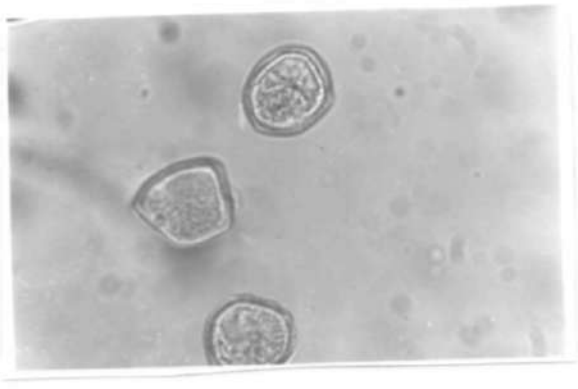
a. Infected leaves



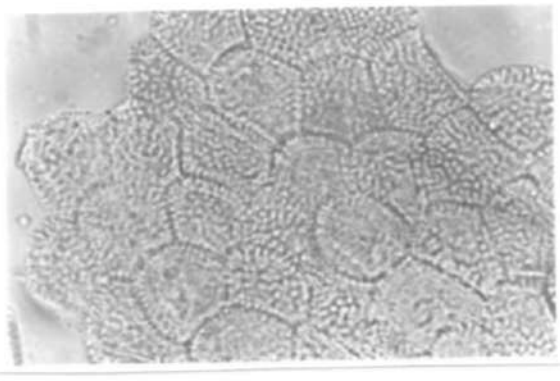
b. Pycnium (section)



c. Aecium (section)

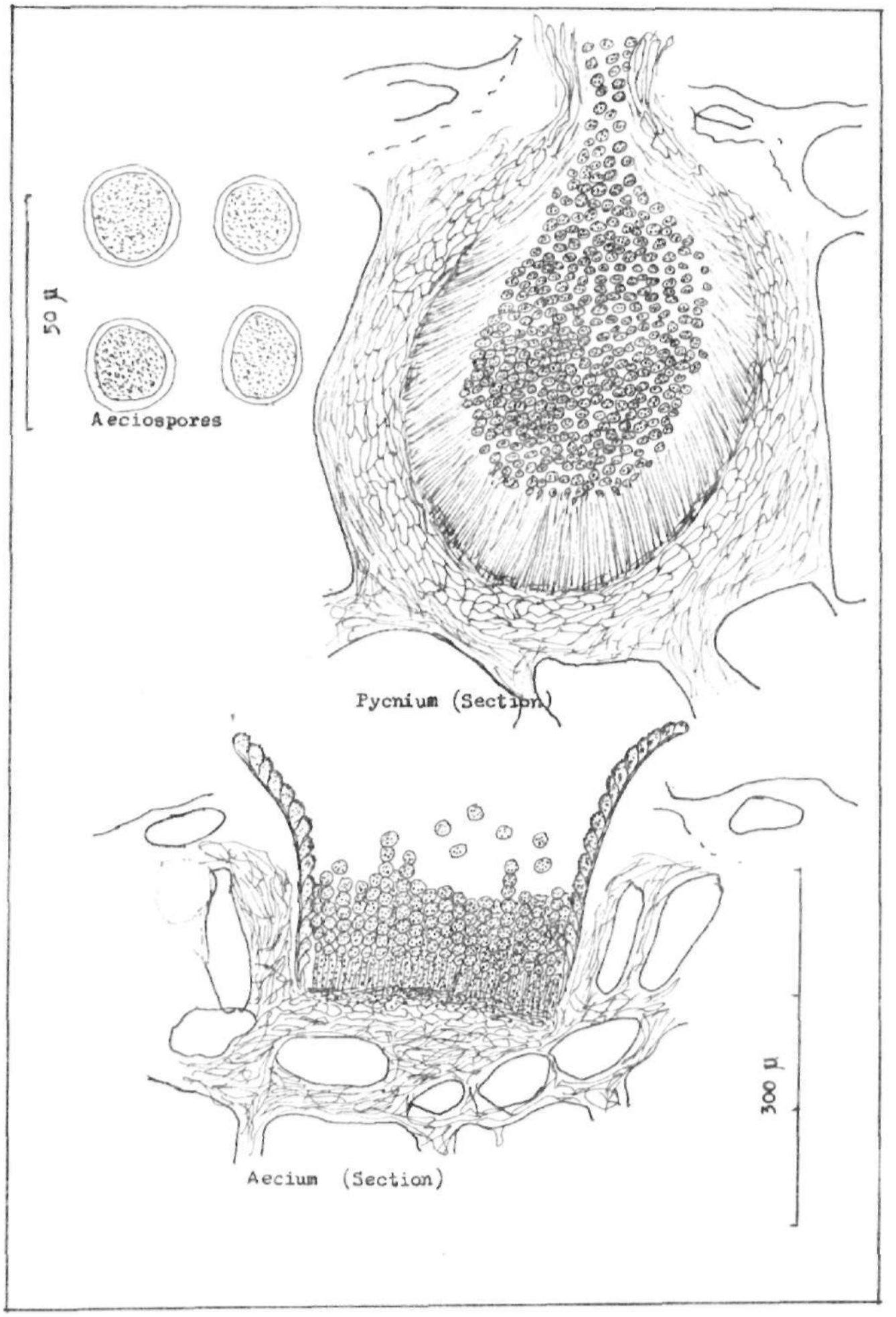


d. Aeciospores



e. Peridial cells

PLATE XXVII. Aecidium hartwegie on Chlorophytum stenopetalum


50 µ
Aeciospores
Pycnium (Section)
300 µ
Aecium (Section)

27. PUCCINIA HETEROSPORA Berkeley and Curtis

(Plate XXVIII ; Fig. 26)

Occurrence :

The hosts Sida ovata L. and S. urens L. are common weeds grow on waste lands in most of the tropical countries. In Nigeria, both the hosts are found throughout the country. In Zaria, they remain green even during the dry season. Fresh infection of rust was observed from July onwards and it lasted up to the end of January. Eboh (1978) recorded the same rust on Sida acuta.

Description :

Pycnia, aecia and uredinia : Not observed during the studies.

Telia : Rust spots amphigenous, brick red on the upper surface, lighter on the lower surface; telia hypophyllous, erumpent, epidermis open, compact, dark brown; spores mostly 1 - celled, mixed with few 2 - celled spores, broadly ellipsoid or oblong, rounded or some what narrow at ends, 2 - celled spores slightly constricted at the septum, wall smooth, uniformly thickened at sides up to 2 µ and up to 7 µ at apex, 1 - celled spores measure 19.2 x 16.5 µ (14.5 - 21.6 x 14.5 - 21.5), 2 - celled spores measure 25.2 x 19.2 µ; pedicel attached at the bottom or obliquely at the middle (diorchoid), up to 95 µ long, thin walled, light brown, collapse; aparaphysate.

Identification :

The rust was first recorded by Berkeley and Curtis (1869) on the host Abutilon species. The rust has a wide host range all belonging to the family Malvaceae and enjoys a circumglobal distribution in warmer parts (Arthur, 1934). The rust under study closely resembles in morphology and spore measurements with the original description of Puccinia heterospora and therefore identified as such.

Germination :

The teliospores germinate in situ under very humid conditions especially during the rainy period. A whitish fluffy growth on the surface of the telia represents the germination of the teliospores. When the matured teliospores were floated on drops of sterile distilled water germinated in about 3 hours. The spores did not require any dormancy or other treatment like wetting and thawing. Each teliospore produced four celled basidium which formed one basidiospore from each cell. The basidiospores were borne on short sterigmata. The spores were round to oval, hyaline and thin walled.

The specimens were collected on living leaves of Sida ovata L. and Sida urens L. (Malvaceae) from Zaria on November 10, 1982.



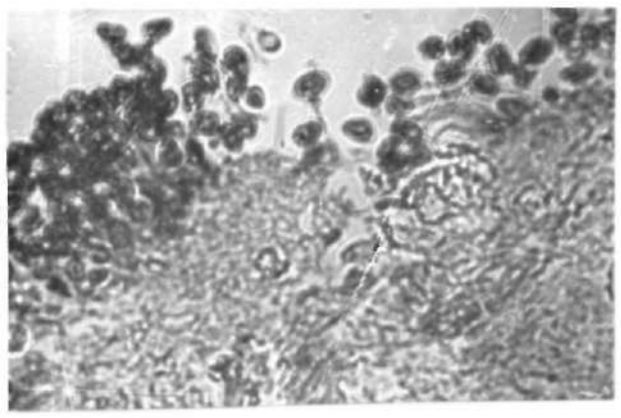
a. Sida urens (Infected plant)



b. Sida ovata (Infected plant)



c. Teliospore (germination)



d. Telium (section)

PLATE XXVIII. Puccinia heterospora on Sida urens and S. ovata

Identification :

Two rusts namely, Puccinia laterita and Puccinia bakoyana Pat. and Har. were recorded on the genus Borraria in the past. The latter is an autoeceous long cycle rust while the former is a microcyclic one. The rust under study is a microcyclic rust and the teliospore characters and measurements closely resemble those of Puccinia laterita and hence described as such. Puccinia bakoyana was recorded by Eboh (1978) on Borreria verticillata (L.) G.F.W.Mey.

Germination :

The fresh teliospores when floated on drops of distilled water and kept under high humidity did not germinate even after the lapse of 72 hours. Perhaps this needs a resting period before germination.

The specimens were collected on living leaves of Borraria radiata G.F.W.Mey (Rubiaceae) from Zaria on October 10, 1982.

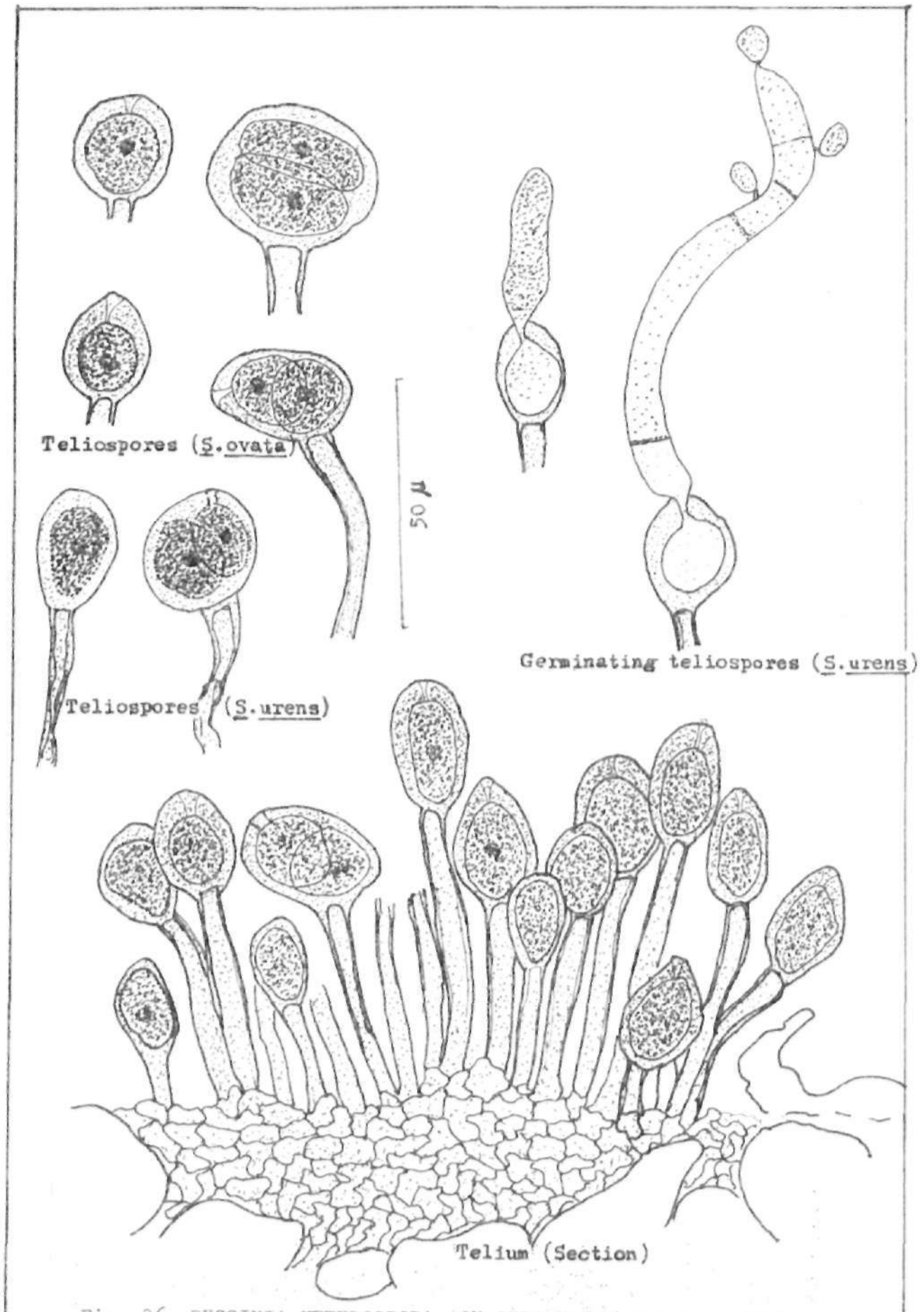


Fig. 26 PUCCINIA HETEROSPORA ON SIDA URENS AND SIDA OVATA

28. PUCCINIA LATERITA Berkeley and Curtis

(Plate XXIX ; Fig. 11 b)

Occurrence :

Borraria radiata G.F.W.Mey is an annual weed growing in waste lands in Zaria and environs. The rust infection starts from the middle of August and continues up to the end of December after which period the host dries up due to the dry weather. Telial stage alone was observed on the host in Zaria.

Description :

Pycnia, aecia and uredinia : Not observed during the studies.

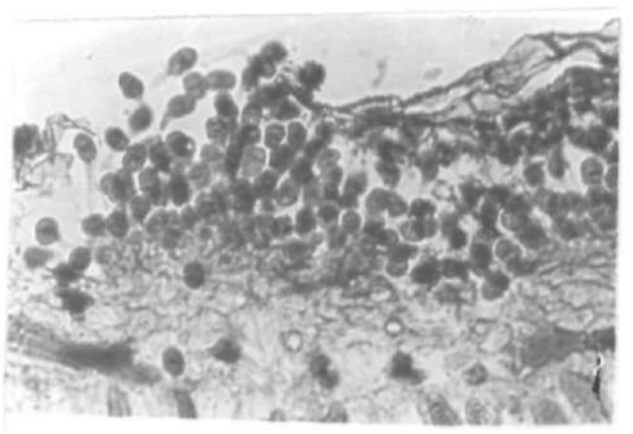
Telia : Spots prominent, amphigenous, yellowish initially, becoming brown, circular; telia epiphyllous, aggregate, formed in circles around the central sorus, epidermis rupture early, erumpent, honey-brown; spores broadly ellipsoid, 2 - celled, septum prominent, constricted at septum, wall uniformly thickened at sides up to 3 µ and up to 5 µ at apex, young spores yellowish brown initially, at maturity becoming dark brown, apex light coloured, the nucleus prominently seen one in each cell, surface smooth, 29 - 38 x 19 - 24 µ; pedicel persistent, sometimes attached oblique, up to 124 µ long and 5 µ broad, thin walled, collapsing, yellowish brown towards the attachment and paler at distal end; 1 - celled spores very common; aparaphysate.



a. Infected plant



b. Teliospores



c. Telium (section)

PLATE XXIX. Puccinia laterita on Borreria radiata

29. AECIDIUM MITROCARPI Sydow

(Plate XXX ; Fig. 27)

Occurrence :

The host Mitrocarpus scaber Zucc. is a common weed in cultivated fields and waste lands in tropical countries. This is commonly observed throughout Nigeria. The rust in its aecidial stage appears by the end of August and continues till the cessation of the wet season in October. There is no previous record of this rust from Nigeria.

Description :

Pycnia and aecia : Pycnia not observed during the studies. Aecia cupulate, surrounded by hyaline, recurved, lacerated peridial cells formed deep in the tissues, measure 220 - 300 µ; peridial cells angular, 20 - 26 x 17 - 22 µ, inner cell verrucose, wall up to 3.5 µ; aeciospores yellowish when fresh, oblong to globose with angular ends, thin walled, surface finely verruculose, 12.0 - 22.8 x 10.0 - 16.6 µ.

Identification :

The measurements of the spores and peridial cells of the rust collected from Zaria were compared with Aecidium mitrocarpi described by Sydow (1914) based on the specimens from Cameroun on the same host species. The details of the spore measurements of the original description and those of the rust under study are given in Table 24.

Table 24. Spore characters of Aecidium mitrocarpi and the rust under study

Rust species	Measurements (in µ)		
	Aecia	Peridial cells	Aeciospores
Aecidium mitrocarpi	250 - 300	20 - 26 x 17 - 22	17 - 22 x 10 - 14
Rust under study	220 - 320	22 - 26 x 17 - 22	12 - 22 x 10 - 17

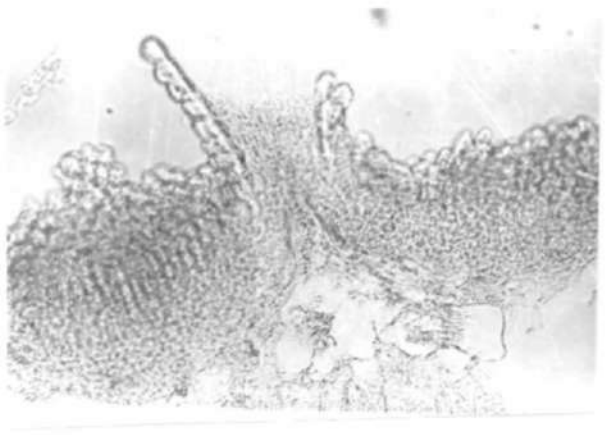
The spore measurements and other morphological chara
of the rust under study closely agree with the original description of Aecidium mitrocarpi and therefore identified as such.

Eboh (1977) considers this rust to be synonym to Puccinia bakoyana Pat. and Har. since he collected the aecial and telial stages on the same host though during different months. He did not experimently prove their relationship. However, during the present studies, observations made between October, 1982 to December, 1983 did not show the presence of telial stage on the host. It is therefore considered that the rust under study to be Aecidium mitrocarpi till it is experimentally proved to belong to Puccinia bakoyana.

The specimens were collected on living leaves of Mitrocarpus scaber Zucc. (Rubiaceae) from Samaru on August 25, 1982. (I M I No. 285920).



a. Infected plant



b. Aecia (section)

PLATE XXX. Aecidium mitrocarpi on Mitrocarpus scaber

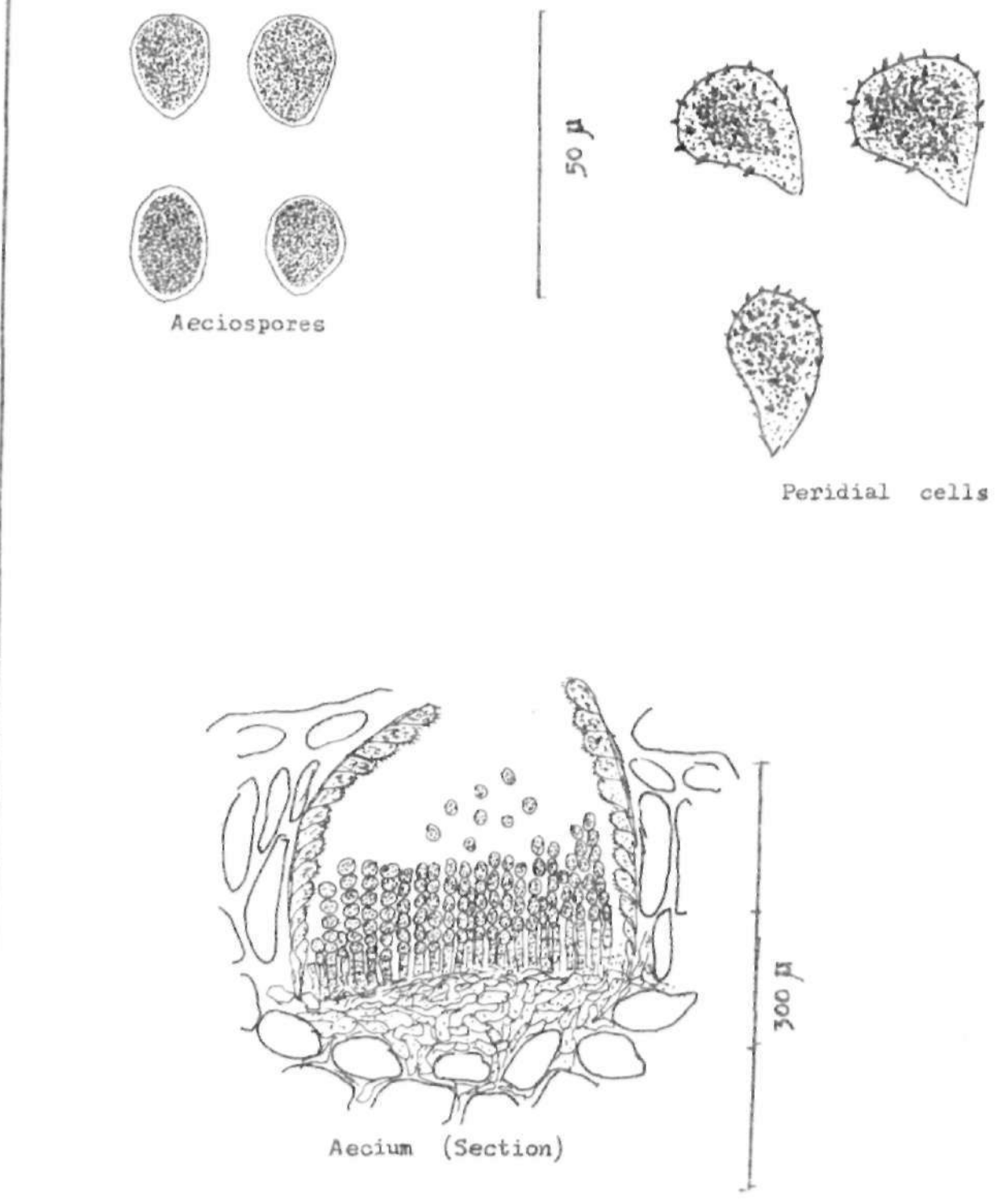


Fig. 27 AECIDIUM MITROCARPI ON MITROCARPUS SCABER

30. AECIDIUM Species nova

(Plate XXXI ; Fig. 28)

Occurrence :

The host Monechma ciliatum Hoechst. is a common weed found in Nigeria. The weed grows on waste lands in Zaria and environs. The aecidium was collected from the host very sporadically. No other record of this rust is available either from Nigeria or other countries. The rust was collected only once during the studies in October, 1982 and further attempts did not succeed. The descriptions are based on single collection.

Description :

Pycnia and aecia : Rust spots blackish brown, amphigenous, circular to irregular; pycnia epiphyllous, spherical, subepidermal, becoming erumpent, surrounded by numerous flexuous, peripheral hyphae, 72 - 84 µ in diam.; spores borne on long thick pedicels, ovate to light brown, mixed with sugary exudate; aecia cupulate, peridiate; peridium marginal, lacerated, whitish, peridial cells hyaline, prominently and strongly echinulate, 27 - 32 x 20 - 30 µ; aeciospores yellowish, catenulate, spherical to ovate with slightly angular sides, thin walled, finely verruculose, 21.6 - 24.0 x 16.8 - 21.6 µ.

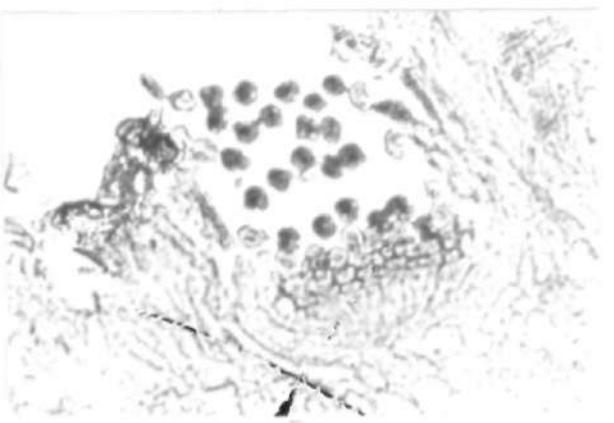
Identification :

There is no record of this rust either from Nigeria or from other countries on this host genus or related hosts and therefore considered to be a new species.

The rust specimens were collected on living leaves of Monechma ciliatum Hoest. (Rubiaceae) from Zaria on October 10, 1982.



a. Pycnium (section)



b. Aecium (section)

PLATE XXXI. Aecidium species nov. on Monecma ciliatum

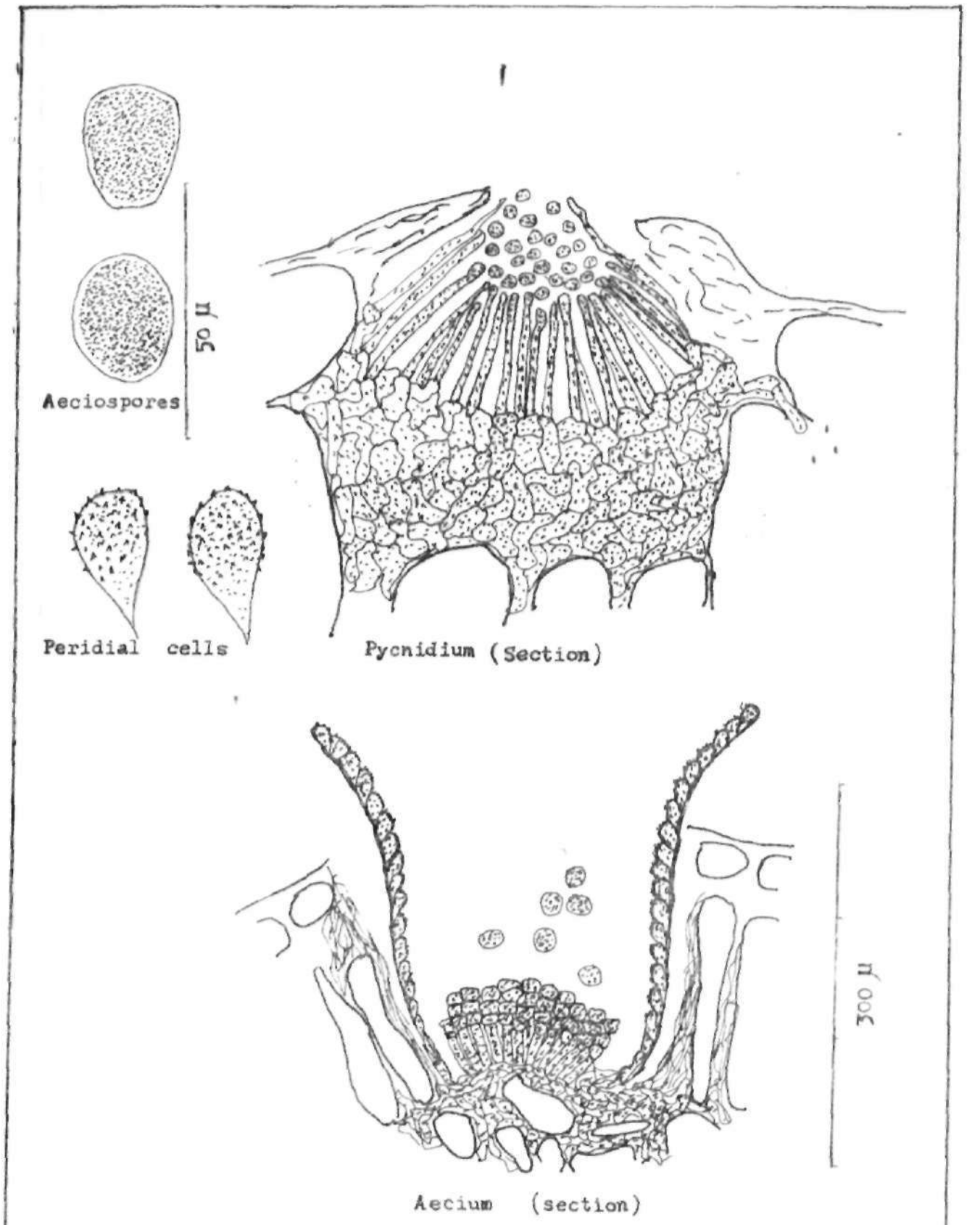


Fig. 28 AECIDIUM SPECIES NOVA ON MONECHMA CILIATUM

LIFE CYCLE OF PUCCINIA SUBSTRIATA VAR. PENICILLARIAE

(Plate XXXII ; Fig. 29)

The life cycle of the rust Puccinia penniseti Zimm. collected on Pennisetum typhoides (americanum) from India was studied for the first time by Ramakrishnan and Sowmini (1948). Solanum melongena L. (egg plant) was found to be the pycnial and aecial host. The nomenclature of this rust was changed by Ramachar and Cummins who named it Puccinia substriata var. indica. Similarly, they substituted the name P. substriata var. penicillariae (Speg.) Ramachar and Cummins for P. penniseti and P. penicillariae the specimens collected from African countries (Cummins, 1971).

While the complete life cycle of the Indian variety of the rust was worked out, it was not known for the African variety (Cummins, 1971). During the present studies, it was observed that pearl millet (Pennisetum americanum) was severely affected by the rust fungus which on examination and comparison with the original description by Cummins was found to belong to P. substriata var. penicillariae. It was also observed that egg plants grown in Zaria and environ were infected by a species of Aecidium under natural conditions. This opportunity was used to study whether the rust on Pennisetum americanum completes its life cycle on the egg plant and other Solanum species available in Zaria as its alternate hosts.

Ramakrishnan and Sundaram (1956[b]) observed by inoculation studies several of Solanum species acting as alternate hosts besides the egg plant. They were successful to get pycnial and aecial stages on Solanum melongena var. insanum, S. pubescence L., S. torvum,

and S. xanthocarpum Schrad. and Wenall. During the present investigations inoculation studies were made using the different Solanum species and the results obtained are given below.

Telial specimens were collected from 'Gero' millet variety ex-Borno from an irrigated crop during April, 1983. They were well dried between filter papers and preserved at room temperature till they were used for inoculation.

The seedlings of the available species and varieties of Solanum were transplanted in pots containing sterilized soil and were kept in enclosed cages till they were used for inoculation. Seedlings free from any disease alone were used in the experiment.

The teliospores were tested for their viability before they were used for inoculation. Viable teliospores germinated in three days when kept floating on sterilised water drops. The test plants were thoroughly washed with sterilised water to remove all dirt and other foreign matter and kept covered under glass bell jars. The telial material was immersed in 5 % sodium hypochloride solution for three minutes and then thoroughly washed with sterilised water to completely remove traces of chlorine.

The teliospores were then removed from the leaf material with the help of a scalpel and were smeared on the upper surface of the test host plants. Before placing the teliospores, the leaf surface of the hosts was thoroughly wetted and then gently rubbed between fingers to remove the waxy bloom so that the water drops might stay on the surface. Soon after placing the teliospores inoculum, the leaves were sprayed with the help of a fine atomiser so that fine droplets could stay on the leaves. The bell jars were thoroughly sterilised before placing them to cover the inoculated plants and the inner surface was also sprayed with

sterilised water to maintain high humidity.

The inoculation was done on the host plants on May 30, 1983 and daily observations were recorded.

Infection process and formation of pycnia and aecia on Solanum melongena

The bell jars were removed daily and sterile water was sprayed on the leaves. No symptom was observed up to the end of nine days from the date of inoculation. On the tenth day, minute, more or less round, yellow specks were observed on the upper surface of the leaves where the teliospores were placed. At this stage the bell jars were removed but the plants were kept under shade. The bottom of the pots were always kept moist. The plants were also sprayed with sterile water as frequently as possible to keep high humidity around the plants. The number of spots increased within two to three days with an enlargement of their size. On the thirteenth day small, shining, erumpent, honey-coloured bodies were seen on the upper surface of the spots. The corresponding lower surface became light yellow and slightly concave in shape. No other symptom was observed. On the fourteenth day, the pycnia were seen prominently with conspicuous ooze which attracted the insects. On the fifteenth day, the lower surface of the infected spots became more concave and on the middle of the spot corresponding to the pycnial formation, slightly bulging and dome like projections were observed. Within the next two days, the aecia started appearing and in the initial stage they were covered by thin, white structures which soon ruptured exposing the light orange coloured aeciospores. Within the course of 18 days, a large number of aecia were observed.

The four species and one variety of Solanum which were available were inoculated and the results are given in Table 25.

Table 25. Results of teliospore inoculation on Solanum species

Host species	No of plants		Days to form	
	Inoculated	Infected	Pycnia	Aecia
Solanum melongena	5	5	13	18
S. melongena var. ex-Ogunmu	5	5	14	19
S. incanum	5	0	0	0
S. anguni	5	0	0	0
S. nigrum	5	0	0	0

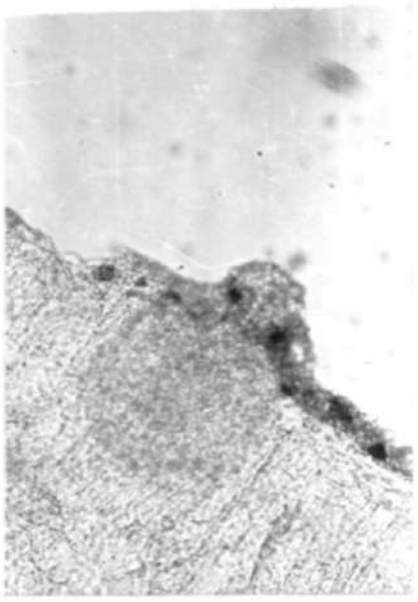
It was observed that out of five different host species including one variety of Solanum inoculated, only two were infected while on others , there was no sign of any infection even up to the end of 30 days. Control plants in each host species were also maintained without inoculation and all of them remained free from infection throughout the experiment.

Conclusion :

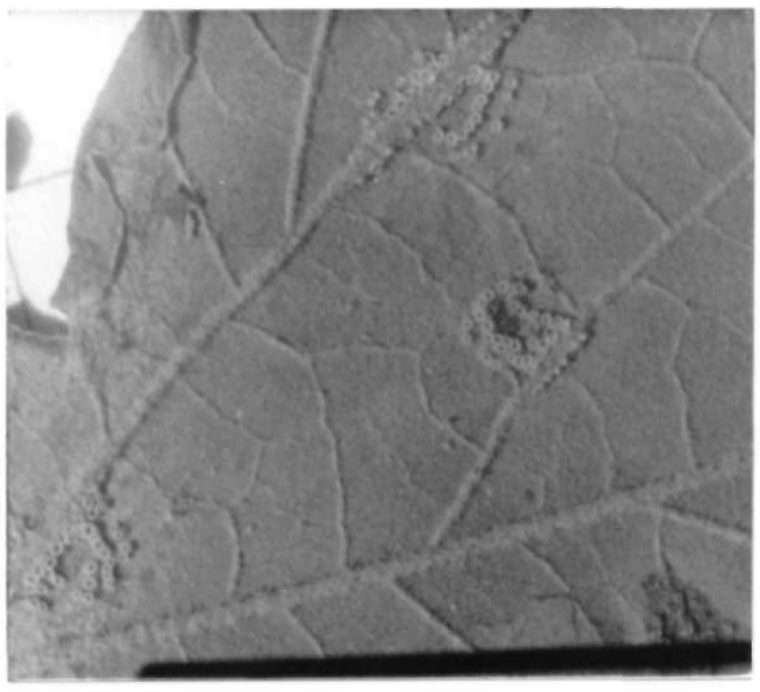
The present results indicate that Solanum melongena (egg plant) and S. melongena var. ex-Ogunmu (an edible variety) serve as alternate hosts for the development of Puccinia substriata var. penicillariae in Nigeria. Solanum melongena acts as the common host for the formation of pycnia and aecia for the different varieties of Puccinia substriata. This is the first record of the complete life cycle of this rust variety.



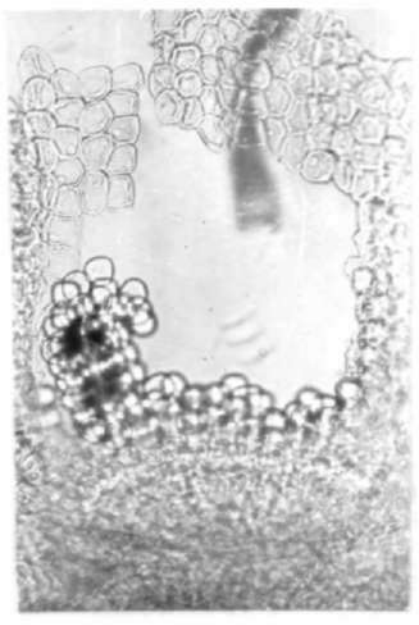
a. Pycnia and aecia on Solanum melongena ex Oganmu



b. Pycnium (section)



c. Pycnia and aecia on Solanum melongena



d. Aecium (section)

PLATE XXXII. Alternate hosts of Puccinia substriata var. penicillariae

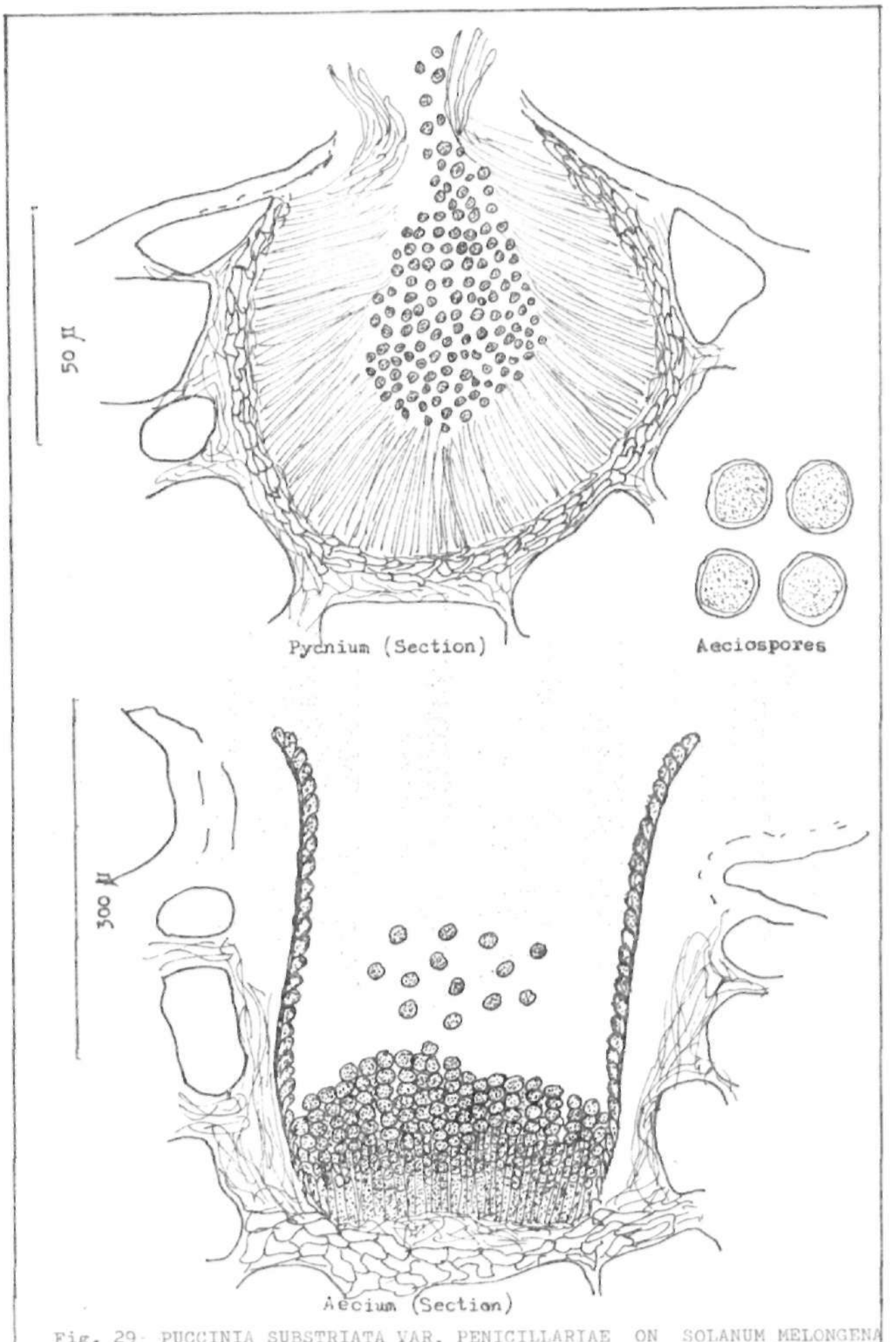


Fig. 29- PUCCINIA SUBSTRIATA VAR. PENICILLARIAE ON SOLANUM MELONGENA

G. LIFE CYCLE OF PUCCINIA HETEROSPORA Berkeley and Curtis

Puccinia heterospora is a microcyclic rust in which pycnia, aecia and uredinia are wanting. It was first studied by Carleton (1904) by inoculating the teliospores collected from Abutilon theophrasti Medic. on its own host and produced teliospores again.

In the present studies, the teliospores collected from Sida ovata were used to inoculate Sida ovata as well as Sida urens since the rust was collected from Zaria on both the hosts.

Inoculation studies :

Seedlings of the hosts Sida ovata and S.urens were raised by sowing matured seeds. They were kept inside the seedling house protected from possible external contamination till the time of inoculation. Seedlings which were absolutely free from any symptom of infection were selected and inoculated using viable teliospores collected from S. ovata. The usual precautions were taken to avoid any external contamination and also provide optimum humidity to encourage a higher infection rate.

Infection process as observed on Sida ovata

The inoculation was done on August 5, 1983. The teliospores were collected from the host leaves with the help of a spear head needle and young teliospores from freshly formed telia alone were used. They were placed on the upper surface of the host leaves which were previously washed thoroughly with sterile water and rubbed with clean sterile bell jars the inside of which were sprayed with sterile water. The process of keeping the leaves wet and spraying the inner surface of the bell jars with sterile water was done every day. After 10 days the inoculated plants were exposed to natural conditions.

No symptom was observed up to 6 days after inoculation. On the 7th day very minute yellow specks appeared in many places on the inoculated leaves. These spots became enlarged within the next three days when the colour changed from yellow to brick-red in the middle and lighter towards the edges and surrounded by a yellow margin. On the corresponding lower surface of the spot, slight bulging of the inoculated plant part was seen. on the tenth day, prominent eruption was seen on the leaf surface with the epidermis in tact but the colour was light brown. During the next two days, the epidermis ruptured partially exposing a dark brown spore mass. The sori became completely exposed the following day giving a cushion like appearance. On a single spot more than one sorus developed.

On examination of the spores, it was confirmed to be identical to those which were used for inoculation, thus confirming that teliospores of Puccinia heterospora inoculated on Sida ovata produced telial stage during the course of 12 days.

Host range:

The rust spores collected from S. ovata and S. urens were used to inoculate both the hosts. The results are given in Table 26.

Table 26. Results of cross inoculation studies

	Reaction on hosts inoculated and incubation period			
	Sida ovata		Sida urens	
	Reaction	Incubation	Reaction	Incubation
Sida ovata	+	13	+	14
Sida urens	+	14	+	14

It was observed that the rust freely passed on from one host to the other and there was no appreciable difference in the incubation period to form the sori.

H. THE HYPERPARASITES OF THE RUSTS

(Plate XXXIII ; Fig. 30 a & b)

Several fungi have been described in the past to parasitise rust fungi (Cunningham, 1931). Among them, a single genus namely, Darluca Cast. is the most prevalent and important one. This hyperparasite has been recorded from many countries of the world, namely, Europe, North and South America, New Zealand, Australia, several countries in Asia and Africa (Laubert, 1925; Kirulis, 1942; Butler, and Bisby, 1931; Tarr, 1955; Kranz, 1969; Mijuskovic and Vucinic, 1974). Tuberculina costaricana Sydow is also reported from various countries like North America, Europe, New Zealand, and India (Kirulis, 1942; Sundaram, 1962; Plydmaa, 1974; Mijuskovic and Vucinic, 1974). On fewer occassions, more than one species of Fusarium have been reported to parasitise rust fungi. From Nigeria, there is no evidence of Fusarium having been reported to parasitise any rust fungus so far. During the present studies undertaken to collect and catalogue the rusts occur in and around Zaria, it was found that several of the rusts were parasitised by Darluca filum and in a single case Tuberculina costaricana was collected. The details of the obeervations made are given in the following paragraphs.

Darluca filum :

While collecting the rust samples on various hosts for study, it was observed that many of them were showing symptoms of shiny, blackish growth of some fungi associated with the rust pustules. In the initial stage, it was mistaken to be the telial stage of the respective rusts. On close examination, it was found that the shiny black bodies were the pycnidial fructification of Darluca filum.

During 1982 wet season, the incidence of the hyperparasite was severe and a large number of rust species were infected. The details of the rusts as well as their hosts examined during 1983 are given in Table 27.

Table 27. Details of the rusts affected by Darluca filum

Rust species	Host (s)	Measurements(in μ)	
		Pycnidia	Pycnidiospores
Phakospsora apoda	Pennisetum pedicellatum	83 - 62	12 - 18 x 3 - 5
Puccinia cyperi	Cyperus reduncus	84 - 59	12 - 18 x 3 - 5
P. cynodontis	Cynodon dactylon	79 - 54	11 - 17 x 3 - 5
P. leucadis	Leucas martinicencis	84 - 60	12 - 18 x 3 - 5
P. ohauensis	Digitaria ciliaris	80 - 51	12 - 18 x 3 - 5
P. romagnoliana	Cyperus rotundus	82 - 56	10 - 17 x 3 - 5
P. substriata var. penicillariae	Pennisetum americanum	79 - 58	11 - 18 x 3 - 5
P. versicolor	Hyparrhenia rufa	78 - 52	11 - 17 x 3 - 4.5
Uredo species nova	Imperata cylindrica	83 - 60	12 - 18 x 4 - 5
Uromyces linearis	Panicum repens	84 - 59	11 - 17 x 3 - 4
	P. subalbidum	82 - 60	12 - 18 x 3 - 5
U. occidentalis	Crotalaria retusa	85 - 59	13 - 17 x 3 - 4
U. setariae-italicae	Brachiaria brizantha	84 - 58	12 - 18 x 3 - 5
	B. lata	83 - 57	12 - 17 x 3 - 4
	B. stigmatisata	84 - 55	12 - 18 x 3 - 5
	Setaria pallide-fusca	80 - 55	12 - 18 x 3 - 4
U. tenuicutis	Sporobolus pyramidatus	84 - 59	11 - 17 x 3 - 5
Standar Error		0.53 0.74	0.17 0.12 0.06 0.11

Variations in the measurements of pycnidia and pycnidiospores of Darluca filum have been reported in the past by many workers. However, they considered all the collections made from different countries on various rusts to be D. filum (Butler and Bisby, 1931; Ramakrishnan and Narasimhalu, 1941; Kirulis, 1942; Padwick, 1945; Chester, 1946; Sundaram, 1962). In the present studies, slight variation in the measurements of pycnidia and pycnidiospores were observed but it was considered that all the collections made from Zaria to belong to Darluca filum.

The mycelium of the parasite spreads through the sori and finally reached the urediniospores destroying the contents of the spores. Many of the infected urediniospores disintegrated. The pycnidia of the hyperparasite were formed in the midst of the urediniospores sub-epidermally and later were exposed except in very few cases like Uromyces tenuicutis where the epidermis remains in tact even after the formation of the pycnidia. The pycnidial wall was made of 2 - 3 layers of dark brown to black pseudoparenchymatous cells. Along the walls, hyaline, irregular growth of the fungus was seen from which arose the fine, filamentous, hyaline conidiophores which ended in conidia. The conidia were spindle shaped, hyaline and uniseptate. Short filamentous cilia-like projections were seen on either ends. The spore wall was thin, smooth and spore contents hyaline.

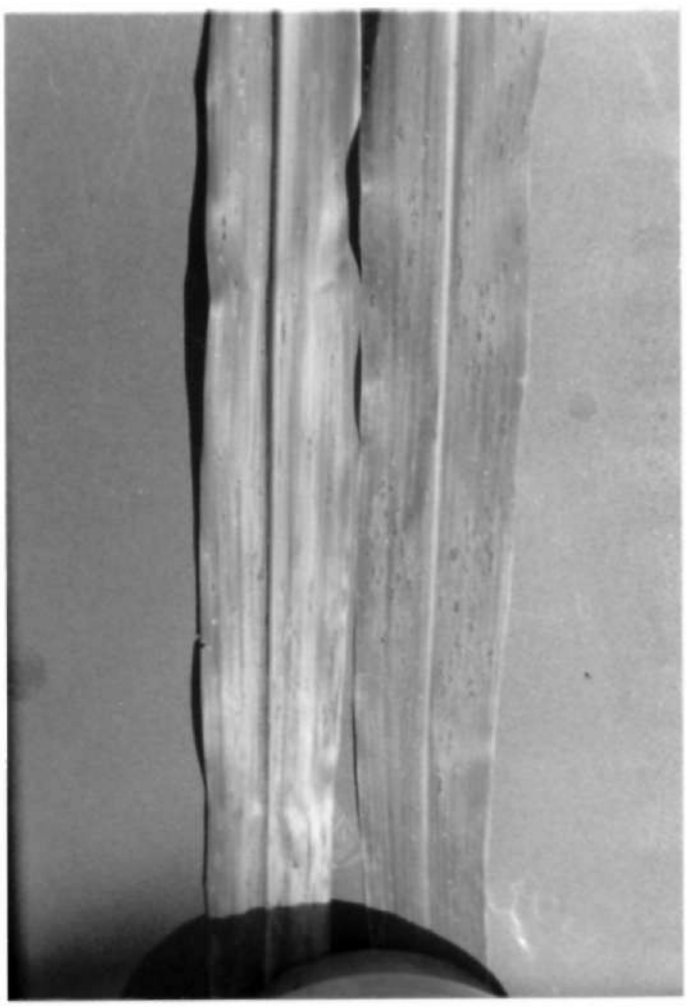
Eudarluca australis

The perithecial stage of Darluca filum namely, Eudarluca australis Speg. was collected from the specimens Puccinia polysora on Zea mays.. The macroscopic symptoms of D. filum and E. australis were identical. The microscopic examination revealed the presence of a number of perithecia associated with the rust sori.

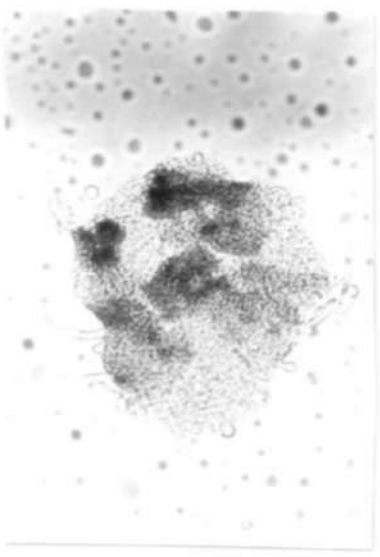
The perithecia were in clusters in the uredinia. They were spherical to pear shaped, ostiolate with narrow opening, the wall made up of 2 - 3 layers of dark coloured pseudoparanchymatous cells, the inner side of which lined with hyaline, thin hymenial layer on which numerous asci were formed. The perithecia measured 90 to 125 µ high and 65 to 80 µ broad. The asci were cylindroclavate, hyaline, narrowing at base and uniformly thin walled. They measured 45 to 80 µ long and 6 to 9 µ broad. Each ascus contained 8 ascospores arranged uniseriately, spindle shaped, hyaline, one septate, constricted at the septum and measured 10 to 20 µ long and 3 to 6 µ broad.

Tuberculina costaricana Sydow

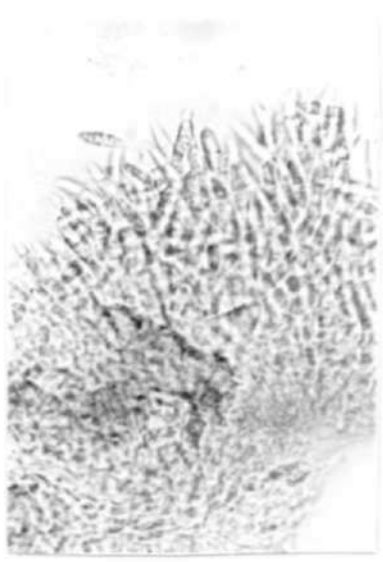
The genus Tuberculina was described by Saccardo (1913) to include the hyphomycetes parasites on rusts. Two members of this genus are commonly observed to parasitise the uredinales. Of them T. costaricana forms cream coloured sporodochium while in the case of T. persicina it is violet in colour. In the present studies, the uredinia of Puccinia versicolor on Rottboelia exaltata was parasitised by T. costaricana. The infection was evident only when the rainfall was continuous and high atmospheric humidity prevailed. The hyperparasite formed white to cream coloured growth on the uredinia. The entire uredinium was filled up by the sporodochium made up of closely packed conidiophores bearing hyaline, elliptical, 1 - celled, smooth walled conidia measuring 8.5 x 6.4 µ (6 - 11 x 4.8 - 7.2); conidiophores long, hyaline, non-septate. Considering the measurements of the conidia and the conidiophores, their morphological characters, the fungus under study is considered to belong to Tuberculina costaricana Syd. This is the first record in Nigeria.



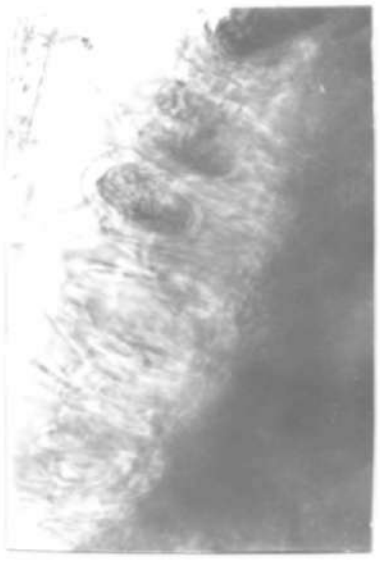
a. Uredinia parasitised by Darluca filum



a. Darluca filum
(pycnidia)



b. Eudarluca australis
(asci and ascospores)



c. Tuberculina costaricana (section

PLATE XXXIII. Hyperparasites on rust

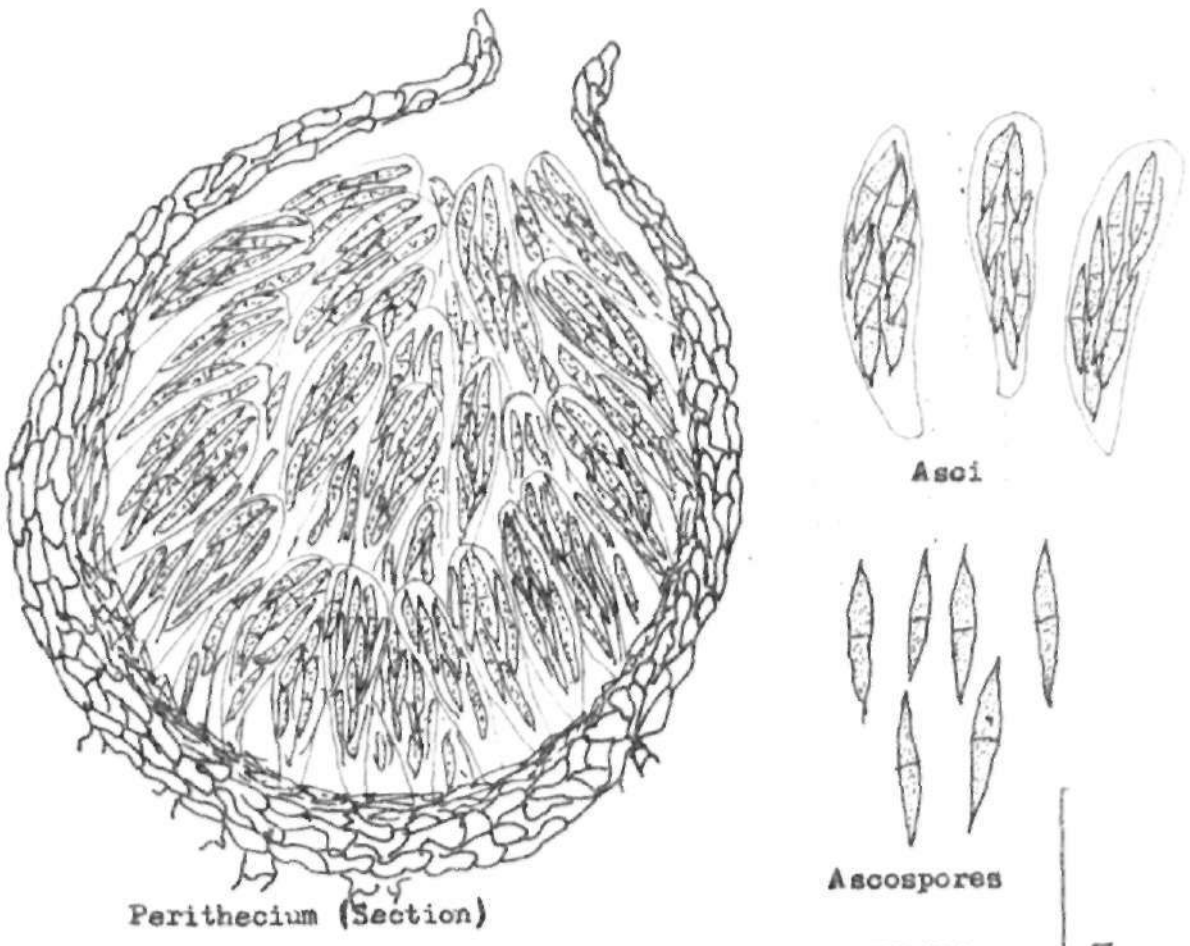


Fig. 30 A EUDARLUCA AUSTRALIS ON PUCCINIA POLYSORA

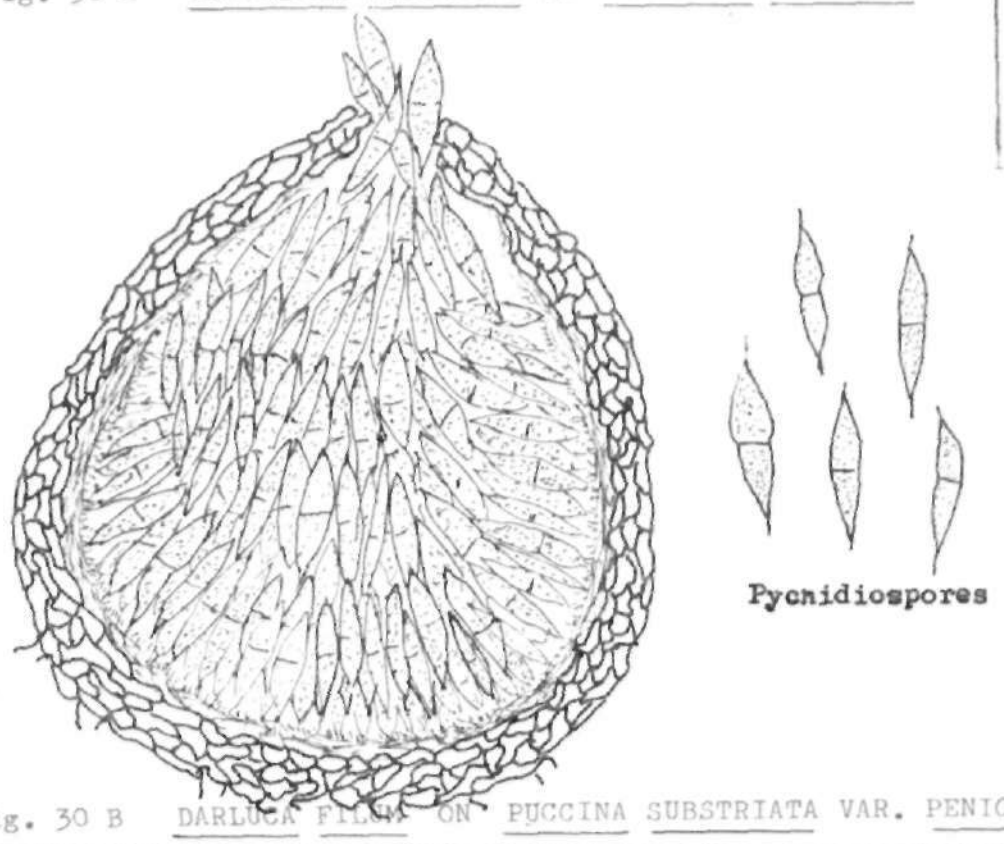


Fig. 30 B DARLUCA FILUM ON PUCCINA SUBSTRIATA VAR. PENICILLARIAE

GENERAL DISCUSSION

Plant rusts caused by fungi belonging to Uredinales have been well known to human beings for a very long time (Ainsworth, 1976). They are not only of academic interest having alternation of generation but are also known to cause heavy losses to agricultural crops and forest trees (Spaulding, 1929; Minkevicius, 1939; Chester, 1946; Littlefield, 1981). Attempts have been made in most of the developed countries to collect, identify and catalogue the rust flora of crop plants, fruit trees, forest trees and wild hosts (Sydow, H. & P., 1904 - 24; McAlpine, 1906; Arthur, 1929; Butler & Bisby, 1931; Wilson & Henderson, 1966; Cummins, 1971; 1978). These are the basic needs before any attempt is made to control the economically important rusts since many of the wild plants act as one of the hosts of the crop rusts in their life cycle. The classic examples are barberry acting as alternate host of wheat stem rust (Puccinia graminis var. tritici); white pine blister rust (Cronortium ribicola) for which the aecial stage occurs on various species of current and goose berry (Butler and Jones, 1955).

Adequate steps are yet needed in many of the developing countries to have a dependable record of the rust flora of economically important crops. However, attempts have been made in a limited way to publish preliminary check lists in some of the African countries notably Rhodesia (Hopkins, 1939), Sudan (Tarr, 1955), Tanzania (Riley, 1960; Ebbels, 1973), Ghana (Piening, 1962), Kenya (Robinson, 1962), and Libya (Kranz , 1965). However, these lists included fungi in general but not rusts in particular.

The check list of Nigerian fungi which included rusts also were published for the first time by West (1938) and was supplemented by many others (Waterston, 1952; Bailey, 1966; Emechebe, 1980).

However, the taxonomy and identification of rusts of Nigeria was first published by Eboh and Obike (1977). Later addition to Nigerian Uredinales were made by Eboh (1978; 1981) and Brian (1981). But no rust flora has been published from Northern Nigeria so far. The present study has resulted in collection of useful observations on the rust flora of this region.

It is interesting to observe that the genera of rusts recorded in Nigeria reflected the earlier observations made in any other tropical country having similar weather conditions (Arthur, 1934; Cummins, 1971; 1978). It is known that out of about 5000 species of rusts recorded in the world, the species belonging to the genus Puccinia form the majority having over 3000 (60 %) species, followed by Uromyces with about 600 (12 %) species; the remaining about 1400 constitute the balance of 28 % (Ainsworth and Bisby, 1971). In the present studies, species belonging to the genus Puccinia form the major group of the rusts collected (48 %) followed by Uromyces (23 %). The genus Ravenelia has been known to be purely a tropical rust particularly infecting the hosts belonging to the Leguminosae. During the study, two species of Ravenelia were collected from the hosts belonging to Leguminosae. Among the various host families affected by rusts in Zaria nearly 50 % belonged to the Gramineae. This fairly represented the global situation (Cummins, 1971).

It was observed from the collections of rusts made in Zaria and environ that the uredinial stage was the most predominent and in a few species, it was collected throughout the year. In most of the collections, the uredinia appeared soon after the onset of the wet season in June and continued multiplication till the cessation of rains in October. During the dry season, due to the drastic fall in the relative humidity (below 15 %), most of the hosts dried up resulting

in the disappearance of the rust organism (Appendix ii).

In a majority of the rust fungi the telial stage was present. However, some rusts like Puccinia polysora and P.sorghi infecting Zea mays which are known to form the telia in other countries where the maximum temperature falls below 24°C during the crop growth, did not form the telia due to poor rainfall.

Four species of Aecidium were collected during the studies. In two of them namely, Aecidium mitrocarpi and Aecidium species nov. on Monechma ciliatum the aecia were scanty. In other cases, they were formed profusely.

By artificial inoculation using teliospores from Puccinia substriata var. penicillariae on the egg plant (Solanum melongena) and a cultivar of it, the aecia were formed throughout the year in the green house. In nature, aecia on egg plants were collected only during the months of July to September. The present studies bring the connection between the aecial hosts and P. substriata var. penicillariae which is the first record (Cummins, 1971). Solanum melongena and few other Solanum species have been reported from India to serve as the alternate hosts for P. substriata var. indica (Ramakrishnan and Sowmini, 1948; and Ramakrishnan and Sundaram, 1956 b).

During the course of the studies 5 rust species, out of 30 were described as new. This has not been reported elsewhere. The morphological characters and spore measurements did not tally with those previously recorded on the host genera or allied hosts. Besides, 12 rusts were found to be new records for Nigeria. This indicates the unexplored area of the study and the ample opportunity to record new or unrecorded rusts in this country if regional surveys are systematically carried out.

Some of the rusts collected had more than one host. Likewise, there were a few hosts affected by more than one rust fungus. Such cases are not uncommon in other countries (Arthur, 1934; Cummins, 1971; 1978). The best example for this is the host range for the rust Puccinia heterospora which has a large number of hosts all over the tropical countries (Arthur, 1934). Wheat (Triticum vulgare) is affected by three economically important rusts namely, Stem rust (Puccinia graminis var. tritici), brown rust (P. triticina) and stripe rust or yellow rust (P. striiformis) (Stakman and Harar 1957). During the present studies also the host Hyparrhenia rufa was found to be affected by more than one rust. Likewise, Uromyces setariae-italicae was collected from four different hosts.

Inspite of the careful search made, Sorghum rust (Puccinia purpurea) was not collected from Zaria. It has been reported from Mokwa during October and November (Adeoti, 1983). The weather conditions appear to be responsible for the absence of the rust in Zaria.

Several hyperparasites have been known in the past to infect the rust pustules especially the uredinia and telia (Laubert, 1925; Butler and Bisby, 1931; Kirulis, 1942; Sundaram, 1962; Mijuskovic and Vucinic, 1974; Plydmaa, 1974). Among them the single species Darluca filum is the most predominant and is known to infect many rusts (Keener, 1934). In Zaria alone it was collected from 17 out of 30 specimens studied. Among the other hyperparasites known, only Tuberculina costaricana was collected from an isolated specimen. In a single case, the perfect stage of Darluca namely, Eudarluca australis parasitising the uredinia of Puccinia polysora on maize was collected. The infection by Darluca filum on maize was earlier recorded from other countries (Biraghi, 1950). The measurements of pycnidia and spores of the specimens D.filum collected from the different rusts during the

studies varied to some extent. However, taking into considerations the records where such variations had been indicated within the species, it was concluded that all the 17 collections belonged to a single species namely, Darluca filum (Laubert, 1925; Kirulis, 1943; Sundaram, 1962; Eriksson, 1966; Kranz, 1969; Plydmaa, 1974).

The significance of hyperparasites in the control of rusts received considerable discussinns in the past (Thirumalachar, 1941; Chester, 1946; Sundaram, 1962). Different opinions have been expressed in the overall effectiveness of hyperparasites for the control of rust. It is true that hyperparasites like Darluca filum, Fusarium species and others could be multiplied on synthetic media and the spore suspension could be spray inoculated on the fresh rust sori. However, before the hyperparasites could invade and parasitise uredinia or telia as the case may be, the damage by the rust to the host would have been done already. Besides, the hyperparasites could not be used as a prophylactic control measure. Therefore, the effectiveness of using hyperparasites to control rusts has very limited practical application. It is likely that the hyperparasites are useful only to a limited extent in reducing the inoculum potential of the rusts.

CONCLUSION:

The survey carried out in Zaria and surrounding even for a single season resulted in the collection of 30 different species of rusts; of which 5 (16 %) were new species and 12 (40 %) were new records to Nigeria. Less than half of the collections made in 1983 alone were recorded in the past. The year 1983 received slightly less than the normal rainfall and it is expected in a normal season the rust flora is likely to include more of unrecorded species.

The life cycle of any of the heteroecious rust fungus has not been worked out or published from Nigeria so far. Solanum melongena and a cultivar of it namely, ex Oganmu were found to act as a pycnial and aecial host for an economically important rust Puccinia substriata var. penicillariae during the studies undertaken. Incidentally, it is the first record to connect the life cycle of the rust. Earlier the life cycle of another variety of the rust namely Puccinia substriata var. indica (= P. penniseti) was worked out from India.

Four species of Aecidium were recorded from Zaria and some of them were collected in large quantities. This suggests the possibility of their connection with commonly occurring rust which needs to be explored.

The hyperparasites though may not be a tool to control the rust fungi still act as a biological means to keep the formation of urediniospores below uncontrollable limit. The large number of rust species affected by the hyperparasites show the natural control of them.

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Appendix i. Weather data of Zaria during 1983 compared with 56 years mean

Month Months	Temperature (°C)				Rainfall (in mm)				Relative humidity (%)		
	1983		56 year-mean		1983		56 year-mean		1983	56 year-mean	
	Min	Max	Min	Max	Rainfall	Rainy days	Rainfall	Morning	Evening	Morning	Evening
JANUARY	13.8	23.6	13.2	29.4	0.0	0	0.2	20.8	16.2	16.3	13.8
February	18.1	32.4	14.6	32.2	0.0	0	1.2	12.0	9.6	14.3	10.3
March	17.0	33.0	19.2	34.8	0.0	0	6.0	14.4	12.8	23.8	13.4
April	19.9	37.5	21.4	34.8	0.0	0	32.0	22.4	12.8	45.1	28.4
May	21.6	34.7	21.9	33.0	73.3	10	114.5	62.6	39.6	65.9	43.6
June	19.6	31.6	19.9	30.4	74.3	9	157.5	72.8	51.9	73.2	56.2
July	23.4	28.8	19.4	28.3	107.5	15	322.0	81.0	64.4	79.5	66.1
August	16.7	28.4	18.6	28.8	259.7	16	264.2	81.2	69.0	81.6	69.6
September	17.3	29.9	19.0	28.2	93.4	12	212.1	76.3	60.4	76.1	62.7
October	14.3	31.8	18.1	31.2	0.0	0	31.6	35.4	25.6	28.5	21.2
November	12.6	32.0	14.9	30.9	0.0	0	1.0	19.4	15.3	20.5	13.8
December	12.9	31.0	13.6	29.8	0.0	0	0.0	17.0	15.3	20.5	13.8

Source : Meteorological section of the Institute for Agricultural Research, ABU, Zaria

Appendix ii . Epidemiological studies of the rusts collected during the year 1983 (continued)

Rust species	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Nov		Dec	
	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T
17. P.versicolor	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	-	+	-
18. Ravenelia sp. nov.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
19. R.tephrosiae	+	+	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+
20. Uromyces appendiculatus var. appendiculatus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	-	-
21. U. linearis	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	+	+	+	+	+	+	+
22. U. occidentalis	+	+	+	+	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+
23. U.setariae-italicae	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	-	+	+	+	+	+	+	+	+
24. U. tenuicutis	+	+	+	+	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	+	-	-
25. Uromyces sp. nov.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	+	-	-
	A		A		A		A		A		A		A		A		A		A		A			
26. Aecidum hartwe	-		-		-		-		-		-		+		+		+		+		+			
27. A. jasmini	+		+		-		-		-		-		+		+		+		+		-			
28. A. mitrocarpi	-		-		-		-		-		-		-		+		+		-		-			
29. Aecidium sp. nov.	-		-		-		-		-		-		-		+		+		-		-			
	U		U		U		U		U		U		U		U		U		U		U			
30. Uredo sp. nov.	+		-		-		-		-		-		-		+		+		+		+			

Note : U = Uredinia T = Telia A = Aecia

Appendix ii . Epidemiological studies of the rusts collected during the year 1983 (continued)

Rust species	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Nov		Dec	
	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T	U	T
17. P.versicolor	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	-	-	-
18. Ravenelia sp. nov.	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
19. R.tephrosiae	+	+	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	-	+	-	+
20. Uromyces appendi-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	-	-
culatus var. appe																								
diculatus																								
21. U. linearis	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	+	+	+	+	+	+	+	+
22. U. occidentalis	+	+	+	+	-	-	-	-	-	-	+	-	+	+	+	+	+	+	-	+	+	+	+	+
23. U.setariae-italicae	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	-	+	+	+	+	+	+	+	+
24. U. tenuicutis	+	+	+	+	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	+	-	-
25. Uromyces sp. nov.	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	+	-	-
	A		A		A		A		A		A		A		A		A		A		A			
26. Aecidum hartwe	-		-		-		-		-		-		+		+		+		+		+			
27. A. jasmini	+		+		-		-		-		-		+		+		+		+		-			
28. A. mitrocarpi	-		-		-		-		-		-		-		+		+		-		-			
29. Aecidium sp. nov.	-		-		-		-		-		-		-		+		+		-		-			
	U		U		U		U		U		U		U		U		U		U		U			
30. Uredo sp. nov.	+		-		-		-		-		-		-		+		+		+		+			

Note : U = Uredinia T = Telia A = Aecia

Appendix iii. Details of rust infected hosts under different families

I. CYPERACEAE

1. Cyperus rédencus
2. Cyperus rotundus

II. EUPHORBIACEAE

1. Euphorbia heterophylla

III. GRAMINEAE

1. Andropogon gayanus
2. Brachiaria brizantha
3. B. lata
4. B. stigmatisata
5. Cynodon dactylon
6. Digitaria ciliaris
7. Hyparrhenia bagirmica
8. H. rufa
9. Imperata cylindrica
10. Leersia hexandra
11. Panicum subalbidum
12. P. repens
13. Pennisetum americanum
14. Rottboelia exaltata
15. Sporobolus pyramidatus
16. Zea mays

IV. JASMINACEAE

1. Jasminum dichotomum

V. LABIATAE

1. Leucas martinicensis

VI. LEGUMINOSAE

1. Arachis hypogeae
2. Albizzia chevalieri
3. Crotalaria retusa
4. Tephrosia bracteolata
5. Vigna unguiculata

VII. LILIACEAE

1. Albuca sudanica
2. Chlorophytum stenopetalum

VIII. MALVACEAE

1. Sida ovata
2. Sida urens

IX. RUBIACEAE

1. Borreria radiata
2. Mitrocarpus scaber
3. Monechma ciliatum

Appendix iv . Distribution of hosts under each rust genus

I. **AECIDIUM**

1. JASMINACEAE

Jasminum dichotomum

2. LILIACEAE

Chlorophytum stenopetalum

3. RUBIACEAE

Mitrocarpus scaber

Monechma ciliatum

II. MELAMPSORA

1. EUPHORBIACEAE

Euphorbia heterophylla

III. PHAKOPSORA

1. GRAMINEAE

Pennisetum pedicillatum

IV. PUCCINIA

1. CYPERACEAE

Cyperus reduncus

Cyperus rotundus

2. GRAMINEAE

Andropogon gayanus

Cynodon dactylon

Hyp rrhenia bagirmica

Hyparrhenia rufa

Leersia hexandra

Pennisetum americanum

Rottboelia exaltata

Zea mays

IV. PUCCINIA (continued)

3. LABIATAE

Leucas martinicensis

4. LEGUMINOSAE

Arachis hypogea

5. MALVACEAE

Sida ovata

Sida urens

6. RUBIACEAE

Borreria radiata

V. RAVENELIA

1. LEGUMINOSAE

Albizzia chevalieri

Tephrosia bracteolata

VI. UREDO

1. GRAMINEAE

Imperata cylindrica

VII. UROMYCES

1. GRAMINEAE

Brachiaria brizantha

Brachiaria lata

Brachiaria stigmatisata

Digitaria ciliaris

Panicum repens

Panicum subalbidum

Setaria pallidefusca

Sporobolus pyramidatus

2. LEGUMINOSAE

Crotalaria retusa

Vigna unguiculata