THE NATURAL OCCURRENCE OF ERGOT IN SOUTH INDIA

By K. M. Thomas, T. S. Ramakrishnan and K. V. Srinivasan
(*Agricultural Research Institute, Coimbatore*)

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The occurrence of the genus *Claviceps* in South India has been recorded from time to time by various workers. McRae (1917) described *Sphacelia sorghi* on sorghum in the Madras Province. Ajrekar (1926) has recorded the same fungus on sorghum in the Bombay Province where he noted immature sclerotia invaded by *Cerebella*. Besides, he has observed *Sphacelia* on **Andropogon caricosus* var. *mollicomus*,[1] *A. annulatus*,[2] *Pennisetum alopecuros*,[3] and *Ischaemum pilosum* in the same province. Ergot sclerotia were observed on *P. alopecuros*. Ramakrishnan (1937) has recorded *Sphacelia* on *Panicum ramosum* from Coimbatore. A *Claviceps* on sugarcane has been observed by Thirumalachar (1943) in Mysore.

Experiments on the production of rye ergot were carried out at the Agricultural Research Station, Nanjanad, Nilgiris, in 1941–42. These were successful and before venturing on an expanded scheme of ergot production, a survey was conducted on the Nilgiri plateau, portions of Wynaad (Malabar District), Anamalais (Coimbatore District) and Kodaikanal (Madura District) to note the occurrence of indigenous species of *Claviceps*. The survey was fruitful and several grasses have now been recorded as being infected by the sphacelial and in some cases the sclerotial stages of *Claviceps*. These fungi have been recorded for the first time on these hosts excepting those on *Pennisetum Hohenackeri*, *Oplismenus compositus* and *Brachypodium sylvaticum*. The distribution is fairly widespread over the Nilgiris and Kodaikanal the same host showing infection by the same fungus in the two areas. Below are recorded short descriptions of the fungi and symptoms of the infection on the different host plants arranged according to hosts.

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* The names of these grasses have been changed into:—

[1] *Dichanthium nodosum*

[2] *D. annulatum*

[3] *Pennisetum Hohenaekeri*

(1) *Cynodon dactylon*—Occurrence: Coimbatore, Gudalur, Wynaad (taluk of Malabar) and Naduvattam (Nilgiris) in the months of November to February. Sclerotia elongated, slightly curved 3–4·5 mm. × 1 — 1·5 mm., cream coloured when young but later becoming deep dark neutral grey externally and white internally (observed only at Coimbatore. Plate VII, Figs. 5 and 6). Conidia oblong, elliptical or kidney-shaped, hyaline and measure 16·2 × 5·7 μ (10 — 23 × 3·8 — 7·5). Conidia germinate readily in water with the production of secondary spores at the ends of germ tubes. Germination is very high between 60° and 70° F. but very poor at 40° or 86° F.

(2) *Pennisetum Hohenackeri.*—Occurrence: Coimbatore and a wide-spread area in Wynaad. Sclerotia small, cylindrical, black 3·5—5 × 0·8—1·8 mm. Conidia formed in light brown drops of viscous honey-dew which later dry into black crusty masses, curved, hyaline, with tapering ends and a prominent vacuole, 20·4 × 5·8 μ (16—26 × 3·5—7·5 μ); germinate readily producing secondary and tertiary conidia, germ tubes usually originate from the sides (Text-Fig. 3). Ajrekar has recorded the occurrence of sphacelial and sclerotial stages on this grass from Bombay but no description is given of either of the stages. Conidia of similar type have been recorded on *Brachiaria ramosa* (*Panicum ramosum*) by Ramakrishnan (1937).

TEXT-FIGS. 1–7. Conidia from (1) *Themeda triandra.* × 400. (2) *Cynodon dactylon* (2 spores germinating and producing secondary conidia. × 450). (3) *Pennisetum Hohenackeri* (also showing germination and formation of secondary and tertiary spores. × 450). (4) *Oplismenus compositus.* × 400. (5) *Amphilophis Foulkesii.* × 400. (6) *Chrysopogon zeylanicus.* × 400. (7) *Heteropogon contortus.* × 400.

(3) *Themeda triandra.*—Occurrence: Over most of the upper slopes of the Nilgiri plateau and in Wynaad from July to February. Conidia, hyaline, oblong, often with a slight constriction in the middle, with granular contents the granules collecting into groups at either ends, 18·0 × 5·4 μ

(10·5–17·5 × 3·7–5·5 μ), honey dew in the form of white semi-solid substance protruding out of the spikelet. No sclerotial stage observed.

(4) *Themeda quadrivalvis*.—Occurrence: Kodaikanal and Nilgiri plateau from November to January. Sclerotia elongated, cylindrical, attaining a length of 8 mm., lower portion black with a violet tinge externally, white inside, often tipped with the remnants of the white conidial mass (Plate VII, Fig. 1); conidia oval or round, hyaline with granular contents 4·0 × 3·3 μ (2·3–9 × 2·2–6), forming a whitish mass projecting out of the spikelet. Bits of sclerotia externally sterilised and transferred to tubes containing agar media produce a white mycelial growth. The growth is slow, thick and slightly folded.

(5) *Ischaemum aristatum*.—Occurrence: Enjoys a wide distribution over most of the Nilgiri plateau, Wynaad and Anamalais during the months of July-January. Conidia oblong or elliptical, rarely oval, hyaline, 12·8 × 5·2 μ (7·5–18 × 3–6); honey dew in the form of almost colourless drops at first, but later developing into a white deposit (Plate VII, Fig. 9). Ajrekar has noted a Sphacelia with curved spores on *Ischaemum pilosum* from Bombay.

(6) *Amphilophis Foulkesii*.—Occurrence: Kodaikanal and several places on the Nilgiri plateau from October to February. Sclerotia cylindrical slightly curved, tapering towards the apex, grey in colour with a number of longitudinal grooves, 5 × 1·5 mm., internally white (Plate VII, Fig. 4). Conidia oval to oblong, hyaline 4·6 × 2·8 μ (1·5–9 × 1·5–4·5); honey dew protruding as a white mass out of the spikelet (Text-Fig. 5). The fungus can be readily brought into culture from bits of sclerotia. A white growth with plenty of aerial mycelium develops and large numbers of conidia are formed.

(7) *Amphilophis insculpta*.—Occurrence: Coonoor (Nilgiris District) in January–February. Sclerotia similar to those formed on *A. Foulkesii* upto 6 × 1 mm., conidia oval, elliptic or oblong and measure 3–7 × 1·5–3 μ.

(8) *Chrysopogon zeylanicus*.—Occurrence: All over the open places on the Nilgiri plateau and Kodaikanal, heavily infected from November to January. Sclerotia very prominent, laterally compressed, slightly falcate, a mixture of grey and black outside, white inside, longitudinal grooves and fissures present, 9·5 × 1·6 mm. (6–16 × 1·2 mm.) (Plate VII, Fig. 10). Conidia hyaline, almost triangular, with rounded corners 11·1 × 6·4 μ (6·8–15·8 × 3·7–9) (Text-Fig. 6). The fungus can be readily brought into culture from bits of sclerotia. The growth is thick and white, slow, folded

and spores are found. These spores are triangular or sometimes oblong. Ajrekar has observed a sphacelia with triangular spores on *Andropogon caricosus* var. *mollicomus*. In the sclerotium obtained from *Chrysopogon zeylanicus* traces of the alkaloid (ergotoxine) have been noticed by Mukerji and De (1944).

(9) *Heteropogon contortus*.—Occurrence: In several places at the higher elevations on the Nilgiris, Wynaad, Kodaikanal and Coimbatore. Sclerotia long and slender, greyish black, with the whitish remains of the conidial stage at the apex, white inside, upto 10 mm. × 1-2 mm., not easily separating from the spikelet; conidia (Text-Fig. 7) mostly triangular, 14·6 ×6·2 μ (9·30 ×3-9), hyaline, forming a white mass just protruding out of the spikelet, often drying into flakes over the glumes. The fungus can be brought into culture from bits of the sclerotium. A white thick folded slow growth results, resembling that of the fungus from *Chrysopogon*.

(10) *Cymbopogon polyneuros*.—A sphacelial stage alone noticed on this grass in many localities on the Nilgiris; honey dew at first as colourless or light coloured drops of fluid coming out of the spikelet, later forming a white mass between the glumes; conidia hyaline, almost triangular with rounded corners, measuring 10·4 × 4·9 μ (7·5 × 3·6); occurs in the months of December-January.

(11) *Cymbopogon flexuosus*.—Sphacelial stage alone observed on this grass at Coonoor, and Keti in Januray-February. Honey dew whitish; conidia hyaline, oblong 8·7 × 4·4 μ (6·12 × 3·6), sclerotia not observed.

(12) *Oplismenus compositus*.—On the Nilgiri plateau and the Pulneys (Madura District) between November and March. Sclerotia blackish grey with a green wash at the base where enclosed by the glumes, elongated, 4–10 × 1–1·5 mm. straight or curved, with longitudinal grooves on the surface (Plate VII, Fig. 7); conidia forming white to greenish-white mass, projecting out between the glumes; conidia almost hyaline, oval to elliptic, 4·5 × 2·2 μ (3–6·8 × 1·5–3) (Text-Fig. 4). Padwick and Azmatullah (1943) have described a new species of *Claviceps, C. viridis*, occurring on this grass at Simla. The fungus observed on the Nilgiris and Pulneys appears to be the same as judged from the descriptions of the conidia and sclerotia. Mukerji and De (1944) did not find even a trace of ergotoxine in the sclerotia collected from South India.

(13) *Digitaria chinensis*.—Over a wide area at Kodaikanal in the months of November-December. Sclerotia ·5–1 × ·5 mm., spindle-shaped, dark grey with a violet tinge, projecting from between the lemma and palea,

Conidial mass whitish, translucent conidia varying in shape, oblong or curved, hyaline 16·4 × 4·1 μ (9–24 × 3·6).

(14) *Urochloa reptans.*—Occurrence: in Palghat and Coimbatore in November. Sclerotia small, 2 × 1 mm., cylindrical, dark brown in colour ; conidial mass white rounded and projecting clearly out of the spikelet. Spores hyaline, curved with one or more oil globules. 17·1 ×4·8 μ (15–24 × 3–6). A sphacelial stage has been recorded on this grass by Rhind (1928) from Burma. *Cerebella* was very common on the infected spikelets.

(15) *Agrostis pilosula.*—Common on the downs and roadsides on the Nilgiris (Ootacamund) in December–Januray. The sclerotia are minute and enclosed inside the spikelets, 1–1·5 mm. × ·3–·5 mm., cylindrical or oblong, violet black, with longitudinal fissures (Plate VII, Fig. 2). Conidial mass whitish, spores elliptic to oval, hyaline, 7·2 × 3·9 μ (3–12 × 1·5–6). The infected spikelets can be detected only by close examination on account of the small size.

(16) *Apluda aristata.*—Occurs in Wynaad in January; sclerotia slightly curved, closely clasped by the glumes at the base, dark grey with longitudinal grooves on the surface, 2·5–4 × 1·5–2 mm.; conidia are hyaline, curved or spindle-shaped, 10·9 × 4·9 μ (7·5–15 × 3–7·5).

(17) *Andropogon lividus.*—Sphacelial stage alone is present on this grass on the Nilgiri plateau; conidia, hyaline, oblong, 10·3 × 5·8 μ (7·5–15 × 3–6)

(18) *Brachypodium sylvaticum.*—Occurs in the higher regions of the Nilgiri plateau in October-December; sclerotia black, cylindrical, slightly bent, upto 8 mm., easily shed (Plate VII, Fig. 8); conidia hyaline, oblong to elliptical, 7·4 × 3·6 μ (3–15 × 1·5–6). The fungus can be brought into culture easily from bits of sclerotia. A white dense growth develops on agar media. Later it becomes cream coloured. Large numbers of spores are formed. The fungus was successfully inoculated on Black winter rye. Padwick and Azmatullah (1943) have described *Claviceps purpurea* on this grass from Simla. The fungus observed on the Nilgiris is possibly *C. purpurea.*

It is interesting to note that two species of *Claviceps* observed in the neighbourhood of Simla are present on the Nilgiris and one on the Pulneys also though these places are thousands of miles apart. Till very lately it was believed that ergot is not present in India. It is possible that the absence of a record of these for all these years may be only due to the want of a

critical survey. These fungi may enjoy wider distribution than what is known at present.

Another interesting feature that was observed both during the experiments on ergot production and in the survey was the constant association of two saprophytic fungi, *viz.*, *Cerebella* producing an olive black growth on the infected spikelets and a *Fusarium* giving rise to a pink-red development on the sclerotia and sometimes on the entire spikelet. The former is present throughout the year but the latter makes its appearance only during the moist monsoon months. As a matter of fact these two fungi help a great deal in locating the infected earheads of grasses and can be considered as indicators of *Claviceps*, though they occasionally form a handicap in the production of ergot of rye by affecting the sclerotia. In nature these must have contributed much to keep down the spread of *Claviceps* on the Nilgiris. It has been observed by Langdon (1942) that *Cerebella* does not develop on the inflorescences of grasses unless there was previous infection by the honey dew stage of *Claviceps* and that it serves as an indicator and is responsible for keeping down ergot formation. "The history of ergot can be traced through *Cerebella*."

Subramaniam (1921) has recorded the occurrence of *Cerebella* on different grasses in India. It must be presumed that all these grasses must have been previously infected by *Claviceps* and have to be considered as records of *Claviceps*. Judging by the localities from which the species of *Cerebella* have been recorded it can be definitely said that the genus *Claviceps*, enjoys a much wider distribution in India than has hitherto been believed. These observations lead us to expect *Claviceps* on more grasses, and over a wider area provided careful search is made in the proper season. The months of August to February (moist and cold weather months) are more favourable for *Claviceps* and search has to be conducted only during these months.

In this paper is recorded the occurrence of *Claviceps* on 18 hosts. On 12 of these grasses sclerotia develop while on the rest the sphacelial stage alone has so far been observed. A correct identification of the species of *Claviceps* can be attempted only after the germination of the sclerotia and the observation of the morphology of the stromata, asci and ascospores. The results of cross inoculation experiments may also give additional evidence. It has not been possible to germinate the sclerotia from different grasses during the period. Hence judging from the conidial characters a tentative arrangement into groups has been attempted as in Table I.

TABLE I

Nature of conidia	Range of conidial measurements in μ	Host plants
1. Conidia curved or fusoid, sclerotia formed—		
(*a*) Conidia smaller honey dew whitish	10·9–17·6 × 4·6	*Cynodon dactylon* *Urochloa reptans* *Digitaria chinensis* *Apluda aristata*
(*b*) Conidia bigger, honey dew dark coloured	20·4 × 8·8	*Pennisetum Hohenackeri*
2. Conidia mostly triangular, sclerotia usually formed ..	10·4–14·6 × 4·9–6·6	*Chrysopogon zeylanicus* *Heteropogon contortus* *Cymbopogon polyneuros*
3. Conidia small, oval or round, sclerotia developed	4·0–7·4 × 2–3·9	*Brachypodium sylvaticum* *Agrostis pilosula* *Amphilophis Foulkesii* *Amphilophis insculpta* *Themeda quadrivalvis*
4. Conidia bigger, oblong, only sphacelial stage .. .	8·7–13·0 × 4·4–5·8	*Themeda triandra* *Ischæmum aristatum* *Andropogon lividus* *Cymbopogon flexuosus*

Of the above, the third group appears to be *C. purpurea*. At least three other species can be formed from the rest. Further studies on the germination of sclerotia and the extent of host range are in progress.

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SUMMARY

A survey was conducted on the upper slopes of the Nilgiri plateau, the Pulneys (in the neighbourhood of Kodaikanal), Wynaad (Malabar and Nilgiris) and portions of Anamalais to find out if any indigenous ergots are present. *Claviceps* was observed on 18 species of grasses. All of these except three are new records. On twelve of these both the sphacelial and sclerotial stages were observed. On the rest the sphacelial stage alone was present.

The fungi collected could be tentatively differentiated into five groups from the conidial characters. One of these appears to be *Claviceps purpurea*.

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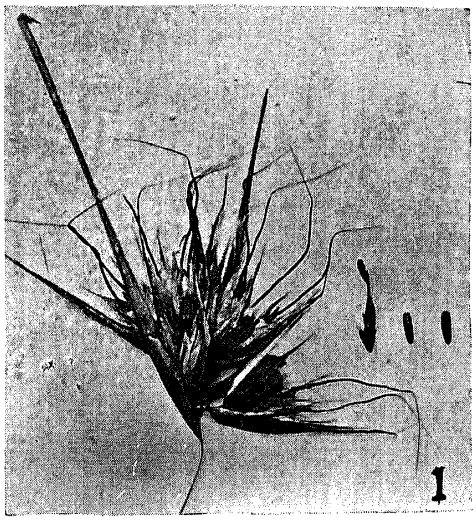
Explanation of Plate VII

Fig. 1. A portion of the infected inflorescence of *Themeda quadrivalvis* and sclerotia.
Fig. 2. Infected inflorescence of *Agrostis pilosula*—sclerotia shown separate.
Fig. 3. *Heteropogon contortus* (sclerotia marked ×).
Fig. 4. *Amphilophis Foulkesii* (sclerotia marked ×).
Fig. 5. *Cynodon dactylon*—with several sclerotia.
Fig. 6. A single sclerotium from *Cynodon dactylon*. × 100.
Fig. 7. Inflorescences of *Oplismenus compositus* (several sclerotia are seen).
Fig. 8. *Brachypodium sylvaticum* (sclerotium shown separately).
Fig. 9. *Ischæmum aristatum* showing white conidial masses.
Fig. 10. *Chrysopogon zeylanicus* (infected spikelets with sclerotia shown separately).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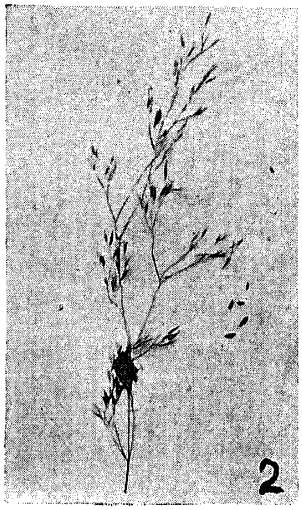
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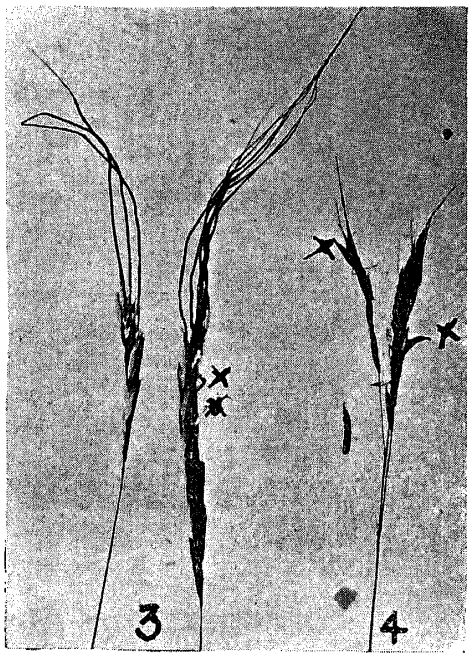
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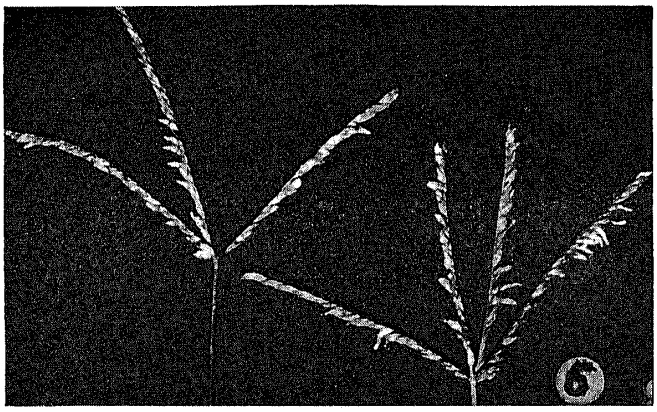
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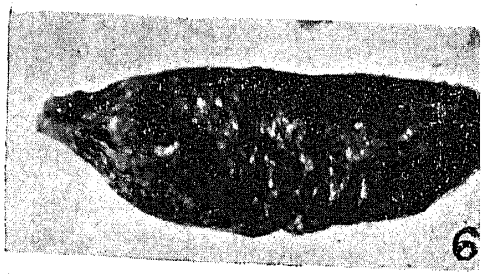
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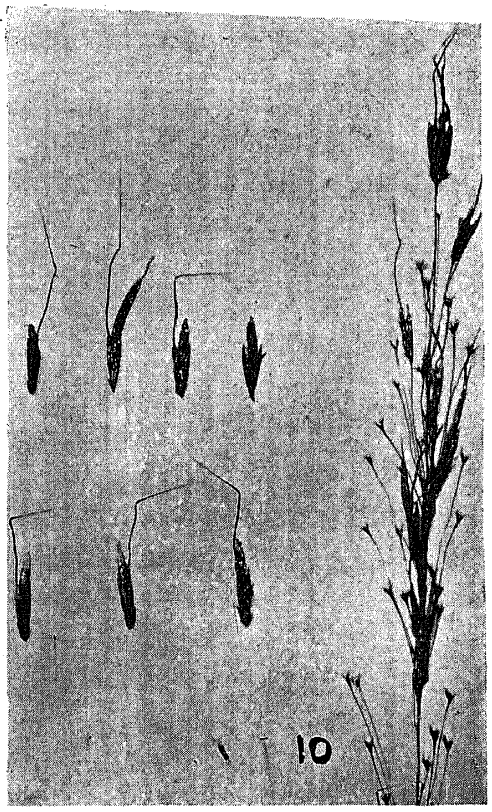
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