

Studies of coprophilous ascomycetes in Kenya. *Podospora* species from wildlife dung

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Moist chamber cultures were made from wildlife dung obtained from national parks in Kenya. Ten dung types produced 28 specimens of *Podospora*. Five species, *Podospora anserina*, *P. argentinensis*, *P. australis*, *P. communis* and *P. minor* are described using their morphological features. *Podospora minor* seems to be a rare species and is recorded for the first time in Kenya. *Podospora communis*, *P. anserina* and *P. australis* are the most common species on dung types examined.

Key words – *Arnium* – biodiversity – conservation – perithecioid – *Schizothecium* – taxonomy

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Introduction

A survey of coprophilous fungi in Kenya that we started three years ago has so far produced four publications (Mungai et al. 2012a, 2012b, 2012c, 2012d) on some interesting ascomycetes groups. We have examined *Ascobolus* Pers., *Saccobolus* Boud., *Schizothecium* Corda., and an assortment of less common Sordariales, followed now by this work on *Podospora* Ces., one of the commonest genera on dung (Lundqvist 1972, Doveri 2004a, 2008, Bell 2005). *Podospora* is predominantly coprophilous, cosmopolitan and normally perithecioid. This genus is strikingly similar to *Schizothecium* Corda, *Arnium* Nitschke ex G. Winter, *Zygopleurage* Boedijn and *Cercophora* Fuckel. It has been treated in great detail by Cain (1934), Mirza & Cain

(1969), Lundqvist (1972), Bell & Mahoney (1995, 1997) Bell (2005) and Doveri (2004a, 2008). Objectives of this survey are to: i) study the taxonomy of *Podospora* from Kenyan wildlife dung, ii) document the ecology and biodiversity of *Podospora* species on different wildlife dung types and, iii) create awareness on the importance of dung fungi in biodiversity conservation and management.

Materials and methods

Twenty-one samples from ten dung types, African elephant (*Loxodonta africana* Blum.), black rhinoceros (*Diceros bicornis* Linn.), Cape buffalo (*Syncerus caffer* Sparrman), zebra (*Equus burchelli* Gray), dikdik (*Madoqua kirkii* Günther), giant forest hog (*Hylochoerus meinertzhageni* Thomas),

giraffe (*Giraffa camelopardalis* Linn.), hippopotamus (*Hippopotamus amphibious* Linn.), impala (*Aepyceros melampus* Licht.) and waterbuck (*Kobus ellipsiprymnus* Ogilbyi) collected from Aberdares Country Club Game Sanctuary, Tsavo East, Aberdares and Nairobi National Parks were cultured in moist chamber. Mungai et al. (2011, 2012a, 2012b) provide details of materials and methods.

Isolation of coprophilous fungi was carried out as previously described by Mungai et al. (2011, 2012a, 2012b). *Podospora* species identification was then performed using a taxonomic key of Mirza & Cain (1969), Lundqvist (1972), Doveri (2004a) and Doveri (2008)

Taxonomy

Podospora Ces.

Podospora in the subfamily Podosporoideae N. Lundq. (Lasiosphaeriaceae Nannf., Sordariales Chadaud ex D. Hawksworth and O.E. Eriksson) is characterised by perithecioid, non-stromatic, more or less membranaceous, dark, superficial to semi-immersed ascomata, clavate to saccate, 4- to poly-spored asci, and ascospores 2-celled at maturity with a dark pigmented upper cell, a hyaline lower pedicel and gelatinous equipment usually as caudae. It is closely related to *Schizothecium* Corda, *Arnium* Nitschke ex G. Winter, *Zygopleurage* Boedijn and *Cercophora* Fuckel. *Schizothecium* is mainly differentiated from *Podospora* by having perithecia with swollen agglutinated hairs, particularly gathered at the neck base (Lundqvist 1972, Doveri 2008).

Unlike *Podospora*, the immature ascospores of *Arnium* are ellipsoidal or fusiform, while the mature ones are non-pedicellate (Lundqvist 1972, Doveri 2004a, Bell 2005). *Zygopleurage* differs from *Podospora* by having ascospores with two opposite dark cells connected by a long cylindrical intercalary cell. *Cercophora* has hyaline vermiform-sigmoid or cylindrical-geniculate ascospores and usually cylindrical-claviform asci with a thickened apical ring and often with sub-apical globules (Lundqvist 1969, 1972, Abdullah & Rattan 1978, Doveri 2008).

Podospora, a cosmopolitan and usually coprophilous genus, was treated in detail by Cain (1934), Mirza & Cain (1969), Lundqvist (1972), Bell & Mahoney (1995, 1997), Bell (2005) and Doveri (2004a, 2008). The morphological characters of peridial hairs, peridium, asci and ascospores have been extensively used in generic delimitation (Cain 1934, Mirza & Cain 1969, Lundqvist 1972, Bell & Mahoney 1995, 1997, Doveri 2004a, 2008, Chang & Wang 2005). Significant importance to circumscribe species of *Podospora* has been attributed to the shape and size of the perithecium and peridial wall cells, the number of ascospores per ascus and the shape of ascospore primary and secondary appendages (Cain 1934, Mirza & Cain 1969, Lundqvist 1972, Doveri 2004a, 2008, Bell 2005, Chang & Wang 2005). The presence or absence of hairs or bristles on the perithecia, such as those found on *P. anserina*, *P. australis* and *P. minor*, is another useful tool in species delimitation (Mirza & Cain 1969, Lundqvist 1972, Doveri 2004a, 2008, Bell 2005). Cultural attributes, though not extensively studied, seem to be important in identifying *Podospora* spp. or groups of related taxa.

In this study, we have used morphological characters to identify the *Podospora* species isolated from wildlife dung in Kenya.

Podospora anserina (Ces. ex Rabenh.) Niessel, Hedwigia 22:156, 1883. (**Fig. 1A–K**)

= *Sphaeria anserina* Ces., in litt.

≡ *Malinvernia anserina* Ces. ex Rabenh., Hedwigia 1: 116, 1856.

= *Sphaeria pauciseta* Ces. in Rabenh, Kl. Herb. Viv. Myc., ed. 1: 116, 1856.

= *Sordaria pauciseta* (Ces.) Ces. & De Not., Comm. Soc. Critt. Ital. 1: 226, 1863.

= *Malinvernia pauciseta* (Ces.) Fuckel, Fungi Rhen. 1002, 1864.

= *Malinvernia breviseta* Fuckel, Jahrb. Nass. Ver. Naturk. 24: 243, 1870.

= *Sordaria anserina* (Ces. ex Rabenh.) G. Winter, Bot. Zeit. 31: 483, 1873.

= *Sphaeria breviseta* (Fuckel) W. Philips & Plowr., Grevillea 2: 187, 1874.

= *Sordaria anserina* f. *ovina* Sacc., Mycoth. Ven. 1179, 1878.



Fig. 1 – *Podospora anserina* (KWSANP004-2009). **A.** Ascomata on dung, note tufts of pointed hairs (arrows). **B** Whole ascoma water mount, note hairs (arrows). **C–D, G–H** Mature ascospores showing pedicels and caudae (arrows). **E** Asci and ascospores showing uniseriate spore arrangement. **F** Squashed ascoma. **I** Paraphyses, note septation (arrow). **J** Ascus showing stipe (arrow). **K** Details of exoperidium. **Scale bars:** **A–B** = 200 μm , **C–D** = 20 μm , **E** = 50 μm , **F** = 500 μm , **G** = 50 μm , **H–K** = 20 μm .

= *Hypocropa erecta* Speg., Anal. Soc. Cient. Argent. 10: 15, 1880.

= *Sordaria erecta* (Speg.) Sacc. Syll. Fung. 1: 239, 1882.

= *Podospora erecta* (Speg.) Niessl, Hedwigia 22: 156, 1883.

= *Sordaria pencillata* Ellis & Everh., Journ. Mycol. 4: 78, 1888.

= *Podospora pencillata* (Ellis & Everh.) Ellis & Everh., North Amer. Pyren.: 131, 1892.

= *Pleurance anserina* (Ces. ex Rabenh.) Kuntze, Rev. Gen. Plant. 3(3): 504, 1898.

= *Pleurance erecta* (Speg.) Kuntze, Rev. Gen. Plant. 3(3): 505, 1898.

= *Pleurance pencillata* (Ellis & Everh.) Kuntze, Rev. Gen. Plant. 3 (3):505, 1898.

= *Sordaria communis* (Speg.) Sacc. va. *tetraspora* Speg., Annal. Mus. Nac. Buenos Aires 6: 253, 1899.

= *Podospora pauciseta* (Ces.) Traverso, Fl. Ital. Crypt. 1, Fungi 1:431, 1907.

≡ *Bombardia anserina* (Ces. ex Rabenh.) Mig., Thomes Krypt. Fl. 10 (1): 123, 1912.

≡ *Schizothecium anserinum* (Ces. ex Rabenh.) E.A. Bessey, Morph. Tax. Fungi:264, 1950.

= *Podospora filiformis* Cailleux, Cah. Maboke 7:102, 1969.

(Adopted from Doveri 2008)

Ascomata perithecioid, semi-immersed to nearly superficial, 380–600 µm high, 300–500 µm diam., scattered or in small groups, covered with few black tubercles and numerous hyphoid hairs, conical or pyriform; *neck* subcylindric, 90–120 µm × 70–80 µm, blackish, coriaceous, with few tufts of agglutinated, rigid, straight, brown, pointed hairs, 100–300 µm long, continuous or sparingly septate. *Peridium* pseudoparenchymatous: endostratum of pale translucent thin-walled polygonal cells 10–25 µm wide; exostratum of thick-walled polygonal cells where hyaline wavy septate hairs originate, 2–4 µm wide. *Paraphyses* cylindrical-moniliform, exceeding the asci, 4.5–6.5 µm broad, septate, with hyaline vacuoles. *Asci* 4-spored, 175–275 × 22–29 µm, clavate, with a thin apical ring, long and slender, lobate stipe. *Ascospores* obliquely uniseriate, two-celled at maturity: spore head 32–36 × 17–20 µm, immature spoon shaped, mature ellipsoidal, somewhat unequilateral, smooth, dark brown,

with a centric germ pore; lower cell (pedicel) cylindrical, 20–30 × 4–5 µm, slightly pointed; *upper cauda*, sub-apical, fairly long, lash-like, furrowed, tip curved, 30–80 × 6.5–8 µm at base; *lower cauda* solid, filiform; additional two to three, short, filiform caudae, with hooked tips, attached to basal part of primary appendage near septum.

Material examined – 7 isolates from dung incubated for between 6 and 20 days – KENYA, Aberdare Country Club Game Sanctuary, Central Province, bushed grassland, GPS S00°19'28.1" E036°55'54.3", altitude 2161 m, giraffe, 29 August 2009, P. Mungai, KWSACC003-2009; Aberdare National Park, Central Province, montane forest, GPS, S00°21'42.0" E036°52'55.9", altitude 2076m, black rhinoceros, 29 August 2009, KWSANP004-2009; Nairobi National Park, Nairobi Province, bushed grassland, GPS S01°20'50.1" E036°47'51.3", altitude 1695 m, hippopotamus, 31 August 2009, P. Mungai, KWSNNP012-2009; Nairobi National Park, Nairobi Province, bushed grassland, GPS 0252737 9847748, altitude 1876 m, Cape buffalo, 27 August 2009, P. Mungai, KWSNNP004-2009; Tsavo East National Park, Coast Province, riverine habitat, GPS S03°21'064" E038°37'501", altitude 514 m, Cape buffalo, 23 September 2008, P. Mungai, KWSTE007A-2008; Tsavo East National Park, Coast Province, riverine, GPS S03°02'29.7", E038°41'35.8", altitude 354 m, dikdik, 27 August 2009, P. Mungai, KWSTE005B-2009; Tsavo East National Park, Coast Province, riverine, GPS S03°21'666", E038°38'772", altitude 514 m, African elephant, 23 August 2009, P. Mungai, KWSTE005A-2009.

Notes – *Pododpora anserina* sect. *Malinvernia* Rabenh. is distinguished from *P. australis* (Speg.) Niessl sect. *Andreanszkyia* Tóth. by the former's smaller non-apiculate ascospores with more complex furrowed caudae and the latter's notably simpler taenioid caudae (Lundqvist 1972, Doveri 2004a, 2008, Bell 2005). The morphology of these collections agree with that observed for this taxon in previous examinations (Cain 1934, Lundqvist 1972, Bell 1983, 2005, Doveri 2004a, 2008). This is a common species on wildlife dung in Kenya.

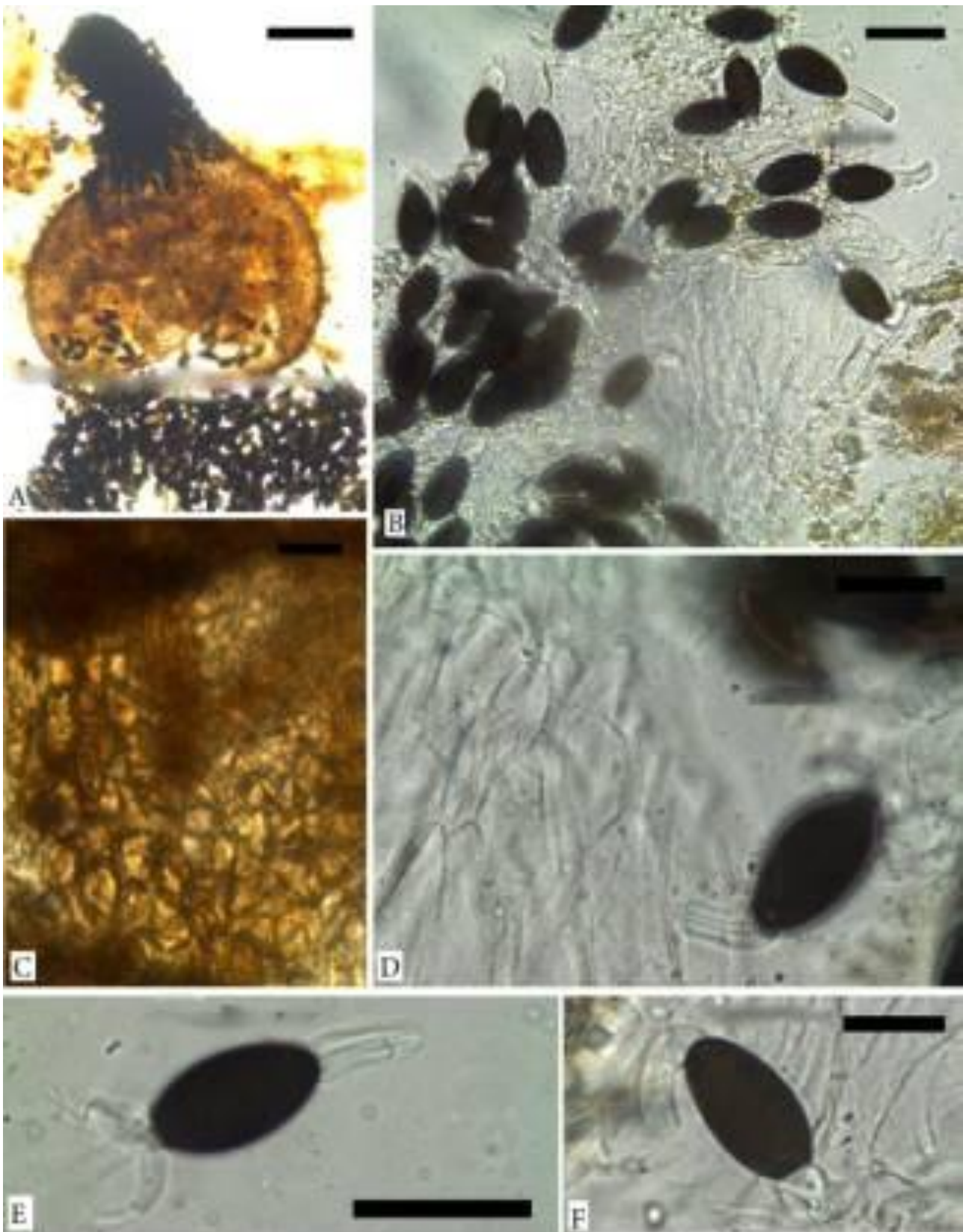


Fig. 2 – *Podospora argentinensis* (KWSACC002-2009). **A** Ascoma squash. **B** Free mature ascospores. **C** Details of exoperidium. **D** Paraphyses. **E–F** Free mature ascospores showing pedicel and caudae. **Scale bars:** **A** = 200 μ m, **B** = 50 μ m, **C–F** = 20 μ m.

Podospora argentinensis (Speg.) J.H. Mirza & Cain, Can. J. Bot. 47: 2008, 1969. (Fig. 2A–F)

≡ *Sordaria argentinensis* Speg., Anal. Mus. Nac. Buenos Aires 23:49, 1912.

≡ *Pleurance argentinensis* (Speg.), C. Moreau, Encycl. Mycol. 25: 252, 1953.

Ascomata perithecioid, immersed or semi-immersed, 400–670 µm high, 200–500 µm diam., scattered, upper portion of perithecia with black tubercles, globose to pyriform. *Peridium* membranaceous; endoperidium of thin-walled polygonal cells; exoperidium composed of brownish thin translucent *textura globulosa-angularis*, cells measuring 6–11 × 5–7 µm. *Neck* short cylindrical, fully covered with black papillae. *Paraphyses* numerous, filiform above, ventricose below, fugacious. *Asci* 8-spored, 180–200 × 30–40 µm, clavate, narrowly rounded at apices, long stipitate. *Ascospores* biserial, two-celled: spore head 27.5–35 × 15–19 µm, ovoid-ellipsoidal, smooth, brown to blackish, thin-walled, with an eccentric germ pore; pedicel often appearing twisted, flattened, cylindrical, or slightly clavate 18–23 µm long, 6.5–9 µm broad at base; upper caudae formed as a lyre-shaped structure, sometimes elongated; lower caudae, fugacious, small, formed as a whorl at the proximal end of the pedicel.

Material examined – 2 isolates from dung incubated 34 and 43 days – KENYA, Nairobi National Park, Nairobi Province, GPS 37M0257082, 9850692, altitude 1668 m, zebra, 20 August 2010, P. Mungai, KWSNNP016-2010; Aberdare Country Club Game Sanctuary in Central Province, S00°19'28.1" E036°55'54.3", altitude 2161 m, zebra, bushed grassland, 30 August 2009, P. Mungai, KWSACC002-2009.

Notes – *Podospora argentinensis* sect. *Rhyphila* Lundq. is closely related to *P. decipiens* (G. Winter ex Fuckel) Niessl of the same section but the former has smaller ascospores (Mirza & Cain 1969, Doveri 2004a, Bell 2005) while the latter does not have a cauda attached at the end of the pedicel (Chang & Wang 2004). This species has been recorded many times from tropical areas and is deemed to be this region's substitute of *P. decipiens* (Mirza & Cain 1969, Lundqvist 1973, Krug & Khan 1989, Richardson 2001), which is common in temperate areas. The characters of

the Kenyan collection are similar to the descriptions made in previous studies (Mirza & Cain 1969, Bell 2005).

Podospora australis (Speg.) Niessl, Hedwigia 22: 156, 1883. (Figs. 3A–G, 4A–G)

≡ *Hypocopra australis* Speg. Anal. Soc. Cient. Argent. 10: 137, 1880.

≡ *Sordaria australis* (Speg.) Sacc., Syll. Fung. 1:239, 1882.

≡ *Pleurance australis* (Speg.) Kuntze, Rev. Gen. Plant. 3(3): 505, 1898.

= *Sordaria apiculifera* Speg. Anal. Mus. Nac. Buenos Aires 6: 251, 1899.

= *Pleurance taenioides* Griffiths, Mem. Torrey Bot. Club 11: 58, 1901.

= *Sordaria taenioides* (Griffiths) Sacc., Syll. Fung. 17: 602, 1905.

= *Sordaria macrura* A. Bayer, Acta Soc. Nat. Moraviae 1: 95, 1924.

= *Pleurance apiculifera* (Speg.) C. Moreau, Encycl. Mycol. 25: 252, 1953.

= *Podospora taenioides* (Griffiths) Cain, Can. J. Bot. 40: 460, 1962.

= *Podospora apiculifera* (Speg.) Mirza & Cain, Can. J. Bot. 47: 2006, 1969.

(Adopted from Doveri 2004a)

Ascomata perithecioid semi-immersed to superficial, 550–850 µm high to 500–620 µm diam., scattered, olive-brown to nearly black, pyriform; the exposed portion covered with long, septate, branched, olivaceous brown and hyaline tipped hairs 2.5–3 µm broad. *Peridium* semi-membranaceous, translucent to slightly opaque; endoperidium of *textura angularis* cells; exoperidium of thick-walled *textura angularis* cells 8–11 × 6.5–8.5 µm. *Neck* 180–240 × 180–190 µm, black, opaque, papilliform to cylindrical; with, septate, rigid hairs 27.5–38.5 µm long, 2–4 µm broad at base. *Paraphyses* cylindrical-moniliform or filiform, longer than asci, 5–6 µm broad, septate, rarely branched. *Asci* 4-spored, 258–307 × 36.5–44 µm, unitunicate, narrowly cylindrical, tapering below into a slender very long stipe, with an indistinct apical apparatus, apex narrow. *Ascospores* obliquely uniseriate at maturity, two-celled: spore head 50.5–55.5 × 25–27 µm, narrowly ovoid to ellipsoidal, symmetrical, dark brown, smooth, thick walled, flattened at base with an apical conspicuous germ pore; lower cell (pedicel) reduced to a conspicuous

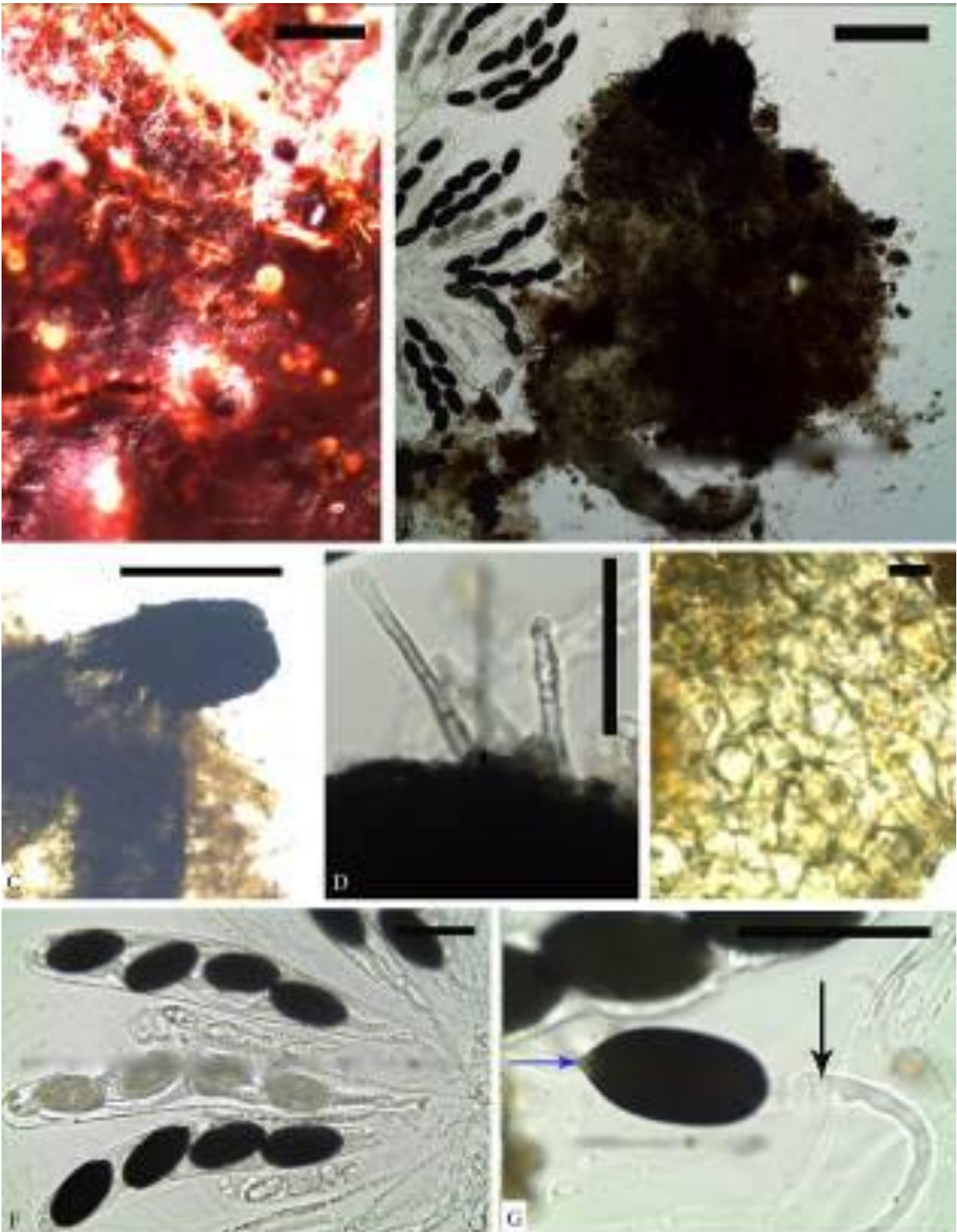


Fig. 3 – *Podospora australis* (KWSACC002-2009). **A** Necks of semi-immersed ascomata on dung. **B** Ascoma squash. **C** Perithecial neck. **D** Septate and hyaline perithecial hairs. **E** Details of exoperidium. **F** Mature and immature asci. **G** Free mature ascospore showing taenioid caudae (black arrow) and apiculum (blue arrow). **Scale bars:** **A** = 1000 μm , **B–C** = 200 μm , **D–E**, **G** = 20 μm , **F** = 50 μm .

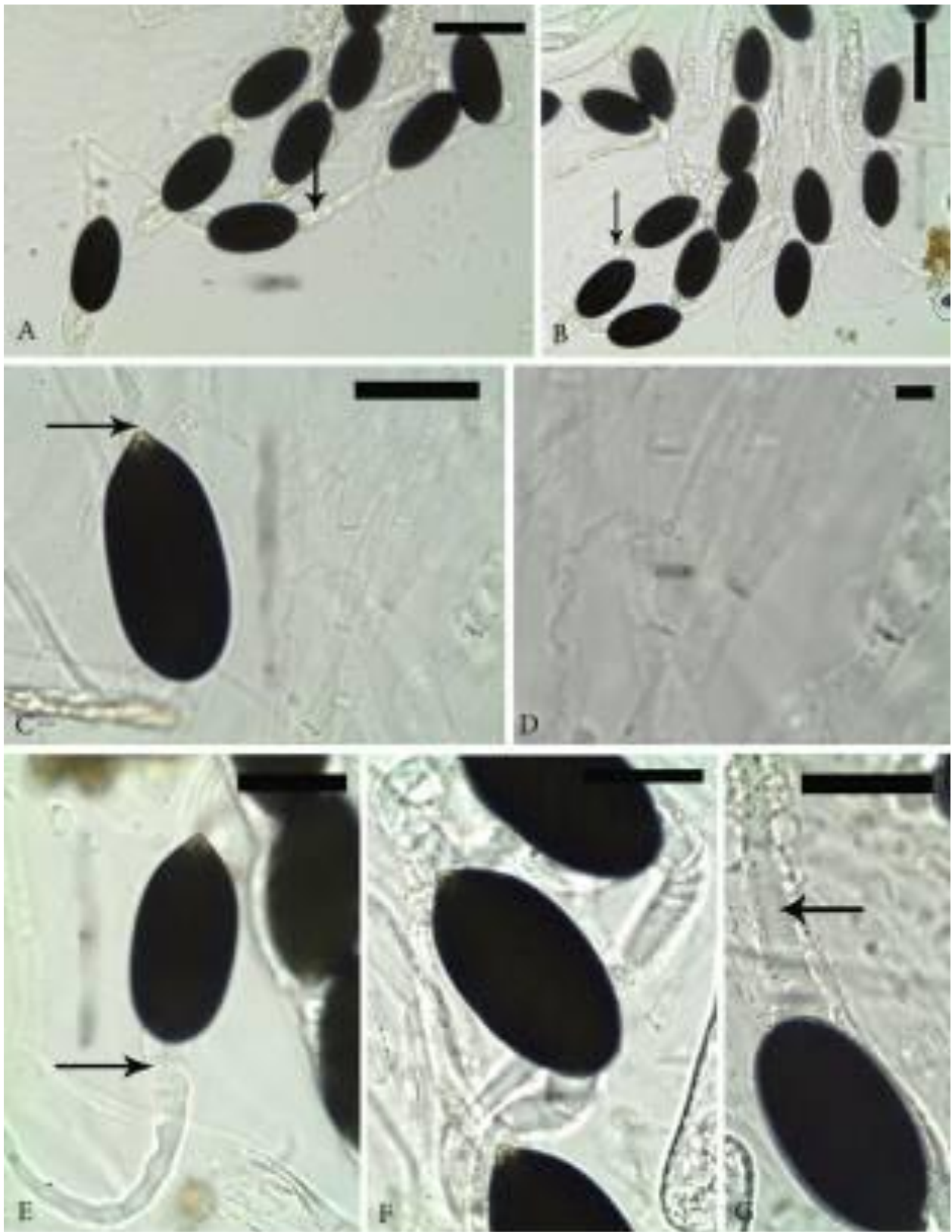


Fig. 4 – *Podospora australis* (KWSACC002-2009). **A–B** Free mature ascospores, note gelatinous equipment (arrows). **C** Mature ascospore among paraphyses, note apiculum (arrow). **D** Details of paraphyses. **E–G** Details of mature ascospores, note caudae with transverse banding (arrows). **Scale bars:** **A–B** = 50 μ m, **C–G** = 20 μ m.

small basal triangular apiculum, hyaline, 4–6.5 × 2–3 µm; *upper cauda* 50–100 µm long, 8–15 µm broad at the base, more segmented (taenioid) in proximal part, longitudinally furrowed and poly-channeled, wavy, attached slightly eccentrically, not covering the germ pore; *lower cauda* similar, long, originating from the basal end of spore, completely covering the apiculum, hollow and taenioid.

Material examined – 4 isolates from dung incubated between 12 and 21 days – KENYA, Aberdare Country Club Game Sanctuary, Central Province, GPS S00°19'28.1" E036°55'54.3", altitude 2161 m, zebra, 30 August 2009, P. Mungai, KWSACC002-2009; Nairobi National Park, Nairobi Province, GPS 37M0257532, 9848948, altitude 1647 m, giraffe, 20 August 2010, P. Mungai, KWSNNP017A-2010; Nairobi National Park, Nairobi Province, GPS 37M0257532, 9848948, altitude 1647 m, giraffe, 20 August 2010, P. Mungai, KWSNNP017B-2010; Nairobi National Park, Nairobi Province, GPS 37M0255297, 9848528, altitude 1693 m, zebra, 20 August 2010, P. Mungai, KWSNNP016-2010.

Notes – *Podospora australis* sect. *Andreanszkyia* (Tóth) Lundq., noted for having a reduced pedicel, is quite unique and is identified by its large ascospores with a small, basal apiculum and taenioid caudae, one on each side of the spore head (Mirza & Cain 1969, Lundqvist 1972, Doveri 2004a, 2008, Bell 2005). It is differentiated from the related *P. anserina* by its larger apiculate ascospores and longitudinally poly-channeled and transversely banded caudae (Lundqvist 1972, Doveri 2004a, Bell 2005). Lundqvist (1972) argues that *P. apiculifera* (Speg.) Mirza and Cain is a depauperate form of *Podospora australis*. Previous records for this taxon in Kenya are from the dung of steenbok, impala, bushbuck, hippopotamus, buffalo, zebra, eland zebra, giraffe and cattle (Caretta et al. 1998, Krug & Khan 1989). It seems to be a very common species on wildlife dung.

Podospora communis (Speg.) Niessl, Hedwigia 22: 156, 1883. (Figs. 5A–E, 6A–E)

≡ *Hypocopra communis* Speg., Anal. Soc. Cie. Argent. 10: 14, 1880.

≡ *Sordaria communis* (Speg.) Sacc. Syll.

Fung. 1: 231, 1882.

= *Sordaria vestita* Zopf, Zeits. Naturw. 56: 556, 1883.

= *Podospora vestita* (Zopf) G. Winter, Rabenh. Krypt. Fl. 1 (2): 176, 1885.

= *Sordaria macrostoma* Speg., Anal. Mus. Nac. Buenos Aires 6: 252, 1899.

= *Pleurage vestita* (Zopf) Griffiths, Mem. Torrey Bot. Club 11: 76, 1901.

= *Bombardia vestita* (Zopf). Mig., Thome's Krypt. Fl. 10 (1): 126, 1913.

= *Sordaria occidentalis* Bat. & Pontual, Bol. Agric. Pernambuco 15: 38, 1948.

= *Pleurage macrostoma* (Speg.) C. Moreau, Encyl. Mycol. 25: 262, 1953.

(Adopted from Doveri 2004a)

Ascomata perithecioid, superficial, 670–1100 × 410–530 µm, scattered or gregarious in small groups, semi-transparent, becoming olivaceous or dark brown, adorned with fine brown hairs of over 40 µm long, disappearing with age, obpyriform. *Neck* conical or cylindrical, 150–385 × 130–150 µm, roughened with small, black papillae or glabrous, opaque, usually curved; ostiole over 80 µm diam. *Peridium* membranaceous, semi-transparent; endoperidium of *textura angularis* cells; exoperidium consisting of yellowish-olive *textura angularis* cells. *Paraphyses* reduced to a mass of elongated vesicles. *Asci* 8-spored, 240–265 × 40–50 µm, unitunicate, clavate, with a narrow tapering broad apex, fairly long stipe, apical ring thin and barely visible. *Ascospores* biseriate, two-celled: spore head 29–40 × 16–25 µm, at first sub-cylindric, later ellipsoidal with truncate base, occasionally asymmetrical, dark to olivaceous brown, opaque, thick walled, with a minute apical germ pore; pedicel 25–42 × 5–6 µm, cylindrical, wider at the base, hyaline, slightly curved in the early stages, straight later; upper caudae four, flattened, short, independent, curved, composed of two filaments, lash-like, larger, 40–50 × 2–4 µm diam, sub-apical, surrounding the germ pore; lower caudae four, 3.5–5 × 1.5–2.5 µm, curved, each independently arising from apex of the pedicel, lash-like, 3.5–5 × 1.5–2.5 µm.

Material examined – 14 isolates from dung incubated between 12 and 64 days – KENYA, Nairobi National Park, Nairobi Province, UTM37 02537515 M 9849130,

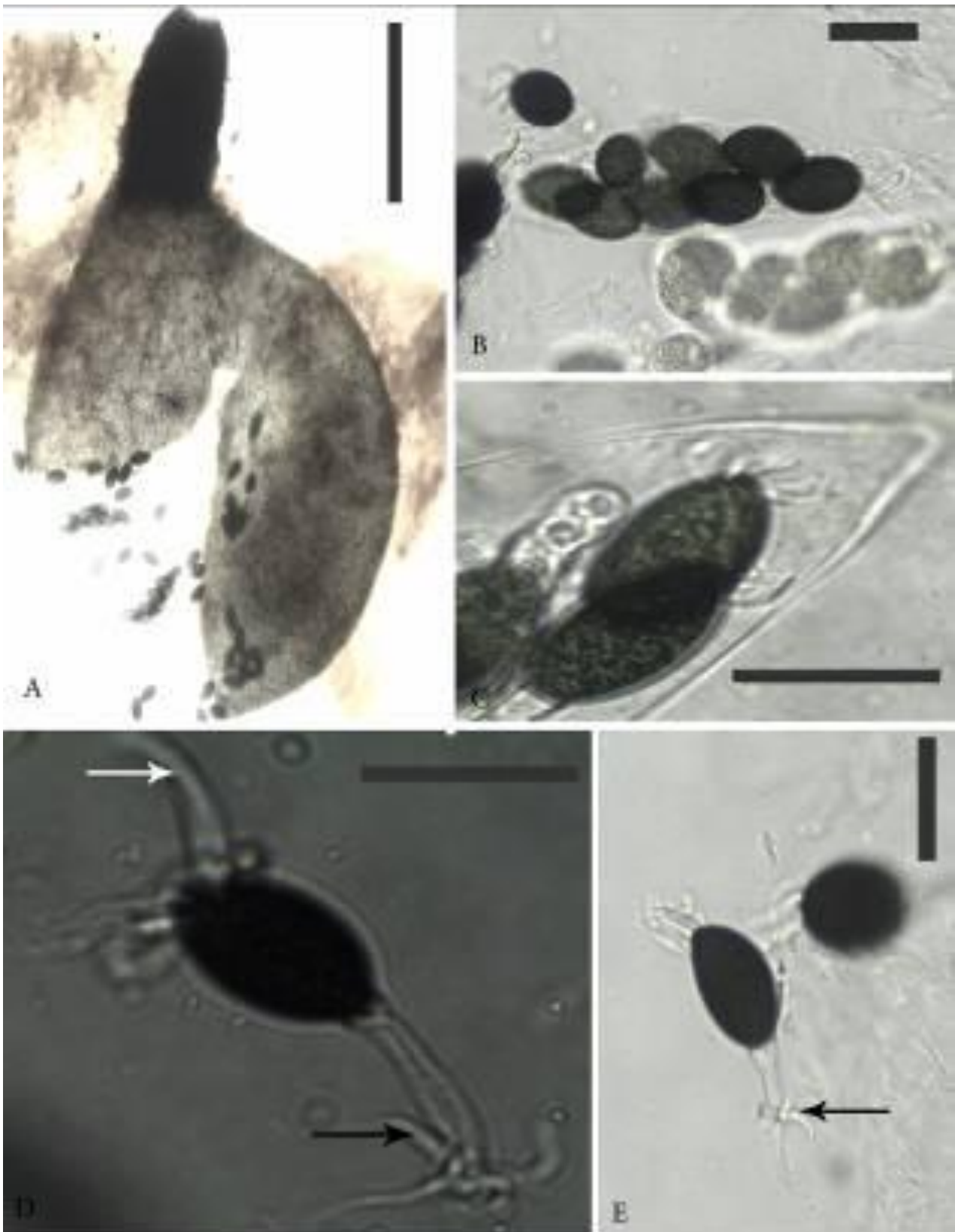


Fig. 5 – *Podospora communis* (KWSNNP001-2009). **A** Ascoma squash. **B** Asci with ascospores in different stages of maturity. **C** Pointed ascus tip. **D** Free mature ascospore showing 4 apical (white arrow) and 4 basal caudae (black arrow). **E** Free mature ascospore showing 4 basal caudae (arrow). **Scale bars:** **A** = 200 μ m, **B**, **E** = 50 μ m, **C–D** = 20 μ m.

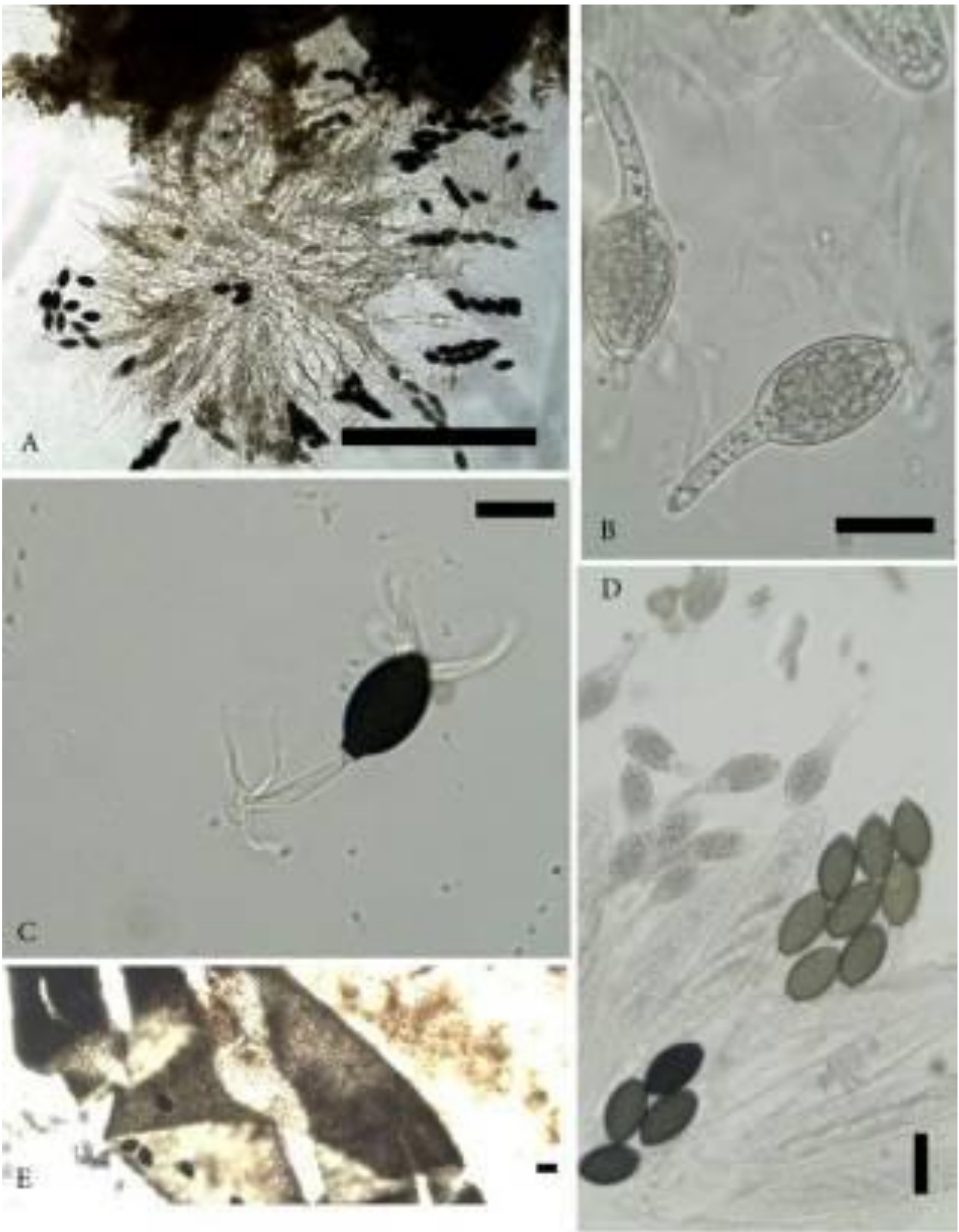


Fig. 6 – *Podospora communis* (KWSNNP001-2009). **A** Centrum contents from squashed ascoma. **B** Immature ascospores. **C** Mature ascospore. **D** Ascospores at various stages of maturity. **E** Details of exoperidium. **Scale bars:** **A, E** = 200 μm , **B** = 20 μm , **C–D** = 50 μm .

altitude 1877 m, Cape buffalo, 18 August 2009, P. Mungai, KWSNNP001-2009; Nairobi National Park, UTM37 0252737 M 9847748, altitude 1879 m, impala, 18 August 2009, P. Mungai, KWSNNP003-2009; UTM37 0252737 M 9847748, altitude 1878 m, black rhinoceros, 18 August 2009, P. Mungai, KWSNNP004-2009; GPS UTM37 0253662 M9847748, altitude 1877m, giraffe, 18 August 2009, P. Mungai KWSNNP005-2009; UTM37 0254976 M 9850544, altitude 1877 m, hippopotamus, 18 August 2009, P. Mungai, KWSNNP006-2009; GPS 37M0255191 9849808, altitude 1693 m, bushed grassland, Cape buffalo, 20 August 2010, P. Mungai, KWSNNP015-2010; Aberdare Country Club Game Sanctuary, Central Province, GPS S00°19'28.1"E036°55'54.3", altitude 2061 m, impala, 30 August 2009, P. Mungai, KWSACC001-2009; GPS S00°19'28.1"E036°55'54.3", altitude 2161 m, bushed grassland, zebra, 30 August, 2009, P. Mungai, KWSACC002-2009; GPS S00°19'28.1"E036°55'54.3", altitude 2161 m, bushed grassland, giraffe, 30 August 2009, P. Mungai, KWSACC003-2009; Aberdare Nairobi National Park, Central Province, GPS S00°19'28.1"E036°55'54.3", altitude 2061 m, black rhinoceros, 29 August 2009, P. Mungai, KWSANP004-2009; GPS S00°21'26.4"E036°51'23.8", altitude 2004 m, montane forest, giant forest hog, 29 August 2009, P. Mungai, KWSANP001-2009; GPS S00°20'23.2"E036°47'11.1", altitude 2075 m, montane forest, waterbuck, 29 August 2009, P. Mungai, KWSANP005-2009; Tsavo East National Park, Coast Province, GPS S03°02'29.7"E038°41'35.8", altitude 354 m, 27 August 2009, P. Mungai, KWSTE004-2009; GPS S03°02'24.9"E038°42'57.1", altitude 343 m, waterbuck, 27 August 2009, P. Mungai KWSTE006-2009; GPS S03°21'666"E038°38'772", altitude 514 m, riverine, African elephant, 23 September 2008, P. Mungai, KWSTE007-2008.

Notes – The Kenyan collections have typical features for the species and compare well with descriptions of same species in previous examinations (Lundqvist 1972, Doveri 2004, Bell 2005). *Podospora communis* belongs to the sect. *Malinvernia* noted for having clavate or dumb-bell shaped immature

ascospores with complex gelatinous equipment at maturity, and peridium lacking a middle gelatinous layer. The main diagnostic characters for *P. communis* include its long, cylindrical pedicel equipped with four short, claw-like, independent gelatinous caudae on the lower end and the presence of four similar caudae on the apex of the spore head (dark cell) (Lundqvist 1972). However, our Kenyan collections have some slight variance with the Australian collection which had three basal caudae (Bell 2005). *P. spinulosa* R.S. Khan & Cain, in the same section, is differentiated from *P. communis* by having short spinules on perithecial neck and more caudae at the base of the pedicel; *P. hyalopilosa* (R. Stratton) Cain has hyaline perithecial neck hairs and a pedicel with only a single apical cauda; *P. multicaudiculata* Cailleux has a slightly hairy neck, shorter asci and multiple but simpler structured caudae; *P. austrohemisphaerica* N. Lundq. has rigid neck hairs, larger spores, multiple caudae, usually four at each pole, additional shorter caudae at base of pedicel and a sheath covering the pedicel and spore head; the neck of *P. deropodalis* R.S. Khan & Cain is covered with short spinules, it has smaller spores but with longer pedicels and variable number of upper caudae and fewer lower caudae; *P. alexandri* Doveri is similar but can be differentiated by its larger ascospores and the inconspicuous caudae when mounted in water (Doveri 2004a, 2004b, 2008). *Podospora communis* is the most widespread and commonest species occurring on several wildlife dung types in Kenya (Table 1).

Podospora minor Ellis & Everh., Amer. Nat. 31: 341, 1897. (Figs. 7A–F, 8A–D, 9A–H)

≡ *Sordaria minor* (Ellis & Everh) Sacc. & P. Syd., Syll. Fung. 14: 493, 1899.

≡ *Pleurage minor* (Ellis & Everh) Griffiths, Mem. Torrey Bot. Club 11: 67, 1901.

Ascomata perithecioid, superficial, 450–810 µm high., 165–470 µm diam., scattered, black, opaque, coriaceous, with short rigid septate, brown and hyaline tipped hairs 23.5–53 × 3–4 µm, conical to pyriform. *Neck* black, cylindrical, 150–200 × 200–225 µm, adorned with stiff septate hyaline tipped hairs. *Peridium* coriaceous, pseudo-bombardioid, 4-layered; outermost peridial wall layer

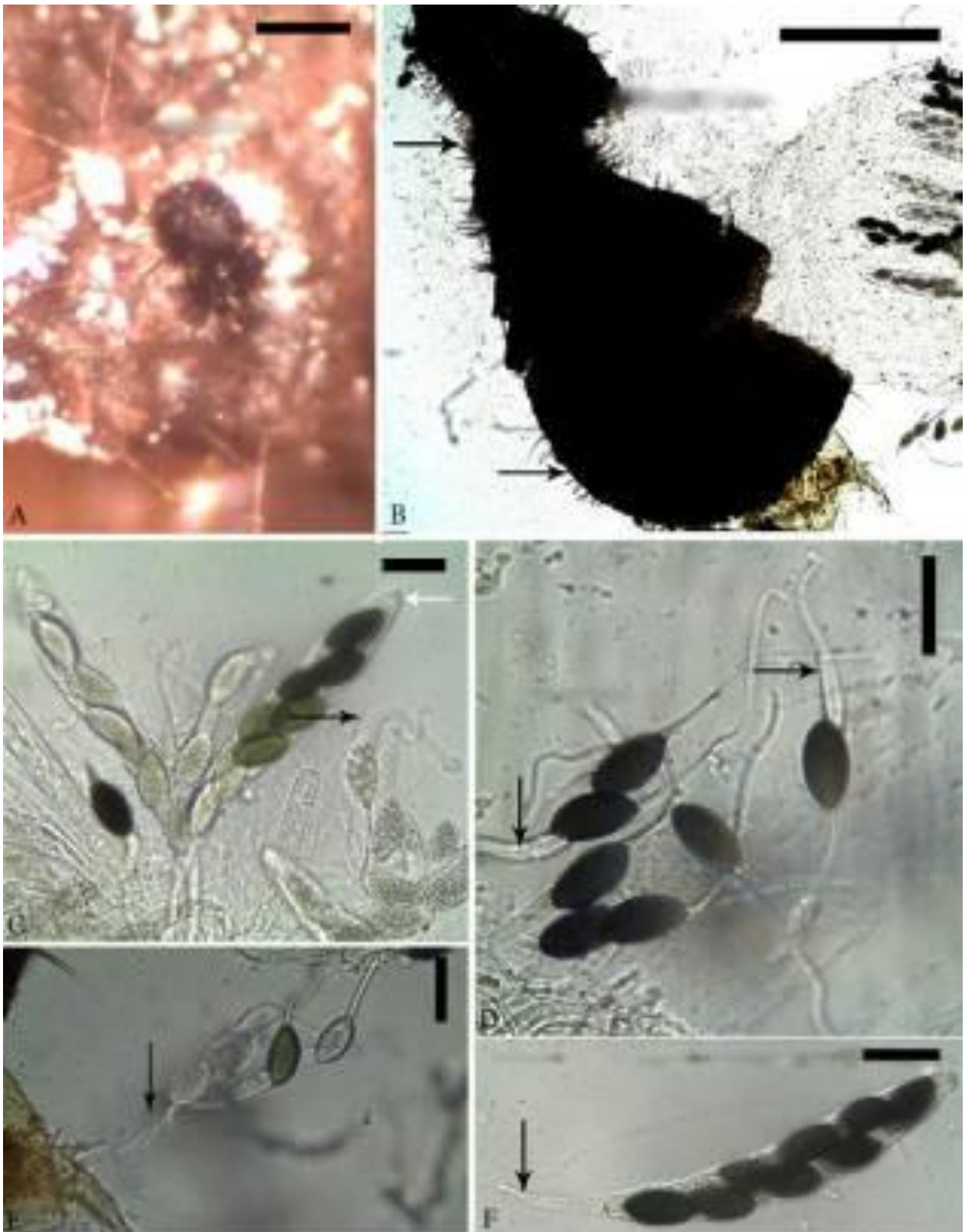


Fig. 7 – *Podospora minor* (KWSACC002-2009). **A** Ascoma on dung. **B** Squashed ascoma mount, note hairs (arrow). **C** Mature and immature asci and ascospores, note apex (white arrow) and gelatinous equipment (black arrow). **D–E** Free mature and immature ascospores, note caudae with circinate ends (arrows). **F** Ascus, showing spore arrangement and stipe (arrow). **Scale bars:** **A** = 500 μm , **B** = 200 μm , **C–F** = 50 μm .

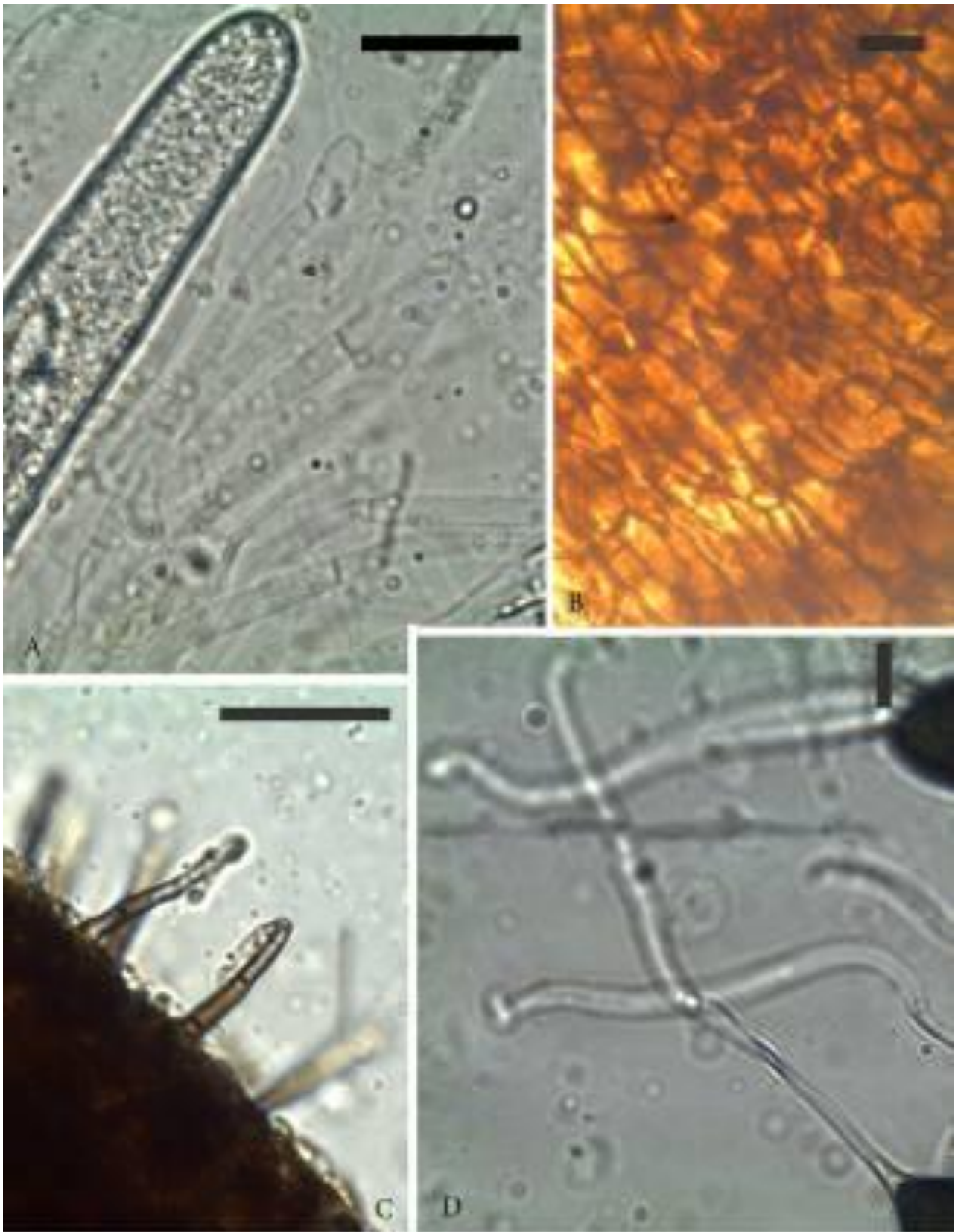


Fig. 8 – *Podospora minor* (KWSACC002-2009). **A** Paraphyses. **B** Details of peridium. **C** Details of ascomatal hairs. **D** Details of caudae. **Scale bars:** A–D = 20 μ m.

Table 1 Occurrence and distribution of *Podospora* spp. in study area

Fungi name	Herb. No.	Dung type	Habitat	GPS/Altitude (m asl)	Date	
<i>Podospora anserina</i>	KWSTE005A-2009	African elephant	riverine	S03°21'66.6	E038°38.772	514
<i>Podospora anserina</i>	KWSANP004-2009	black rhinoceros	montane forest	S00°21'42.0	E036°52'55.9	2076
<i>Podospora anserina</i>	KWSNNP004-2009	Cape buffalo	bushed grassland	0252737	9847748	1876
<i>Podospora anserina</i>	KWSTE007A-2008	zebra	riverine habitat	S03°21'064	E038°37'501	514
<i>Podospora anserina</i>	KWSTE005B-2009	dikdik	riverine	S03°02'297	E038°41'358	354
<i>Podospora anserina</i>	KWSACC003-2009	giraffe	bushed grassland	S00°19'28.1	E036°55'54.3	2161
<i>Podospora anserina</i>	KWSNNP012-2009	hippopotamus	bushed grassland	S01°20'50.1	E036°47'513	1695
<i>Podospora argentinensis</i>	KWSNNP016-2010	zebra	wooded grassland	37M0257082	9850692	1668
<i>Podospora argentinensis</i>	KWSACC002-2009	zebra	bushed grassland	S00°19'28.1	E036°55'54.3	2161
<i>Podospora australis</i>	KWSACC002-2009	zebra	bushed grassland	S00°19'28.1	E036°55'54.3	2161
<i>Podospora australis</i>	KWSNNP016-2010	zebra	wooded grassland	37M0255297	9848528	1693
<i>Podospora australis</i>	KWSNNP017B-2010	giraffe	wooded grassland	37M0257532	9848948	1647
<i>Podospora australis</i>	KWSNNP017A-2010	giraffe	wooded grassland	37M0257532	9848948	1647
<i>Podospora communis</i>	KWSTE007-2008	African elephant	riverine	S03°21'66.6	E038°38.772	514
<i>Podospora communis</i>	KWSNNP004-2009	black rhinoceros	bushed grassland	UTM370252737	M9847748	1878
<i>Podospora communis</i>	KWSANP004-2009	black rhinoceros	montane forest	S00°19'28.1	E036°55'54.3	2061
<i>Podospora communis</i>	KWSNNP001-2009	Cape buffalo	Grassland	UTM3702537515	M9849130	1877
<i>Podospora communis</i>	KWSNNP015-2010	Cape buffalo	bushed grassland	37M0255191	9849808	1693
<i>Podospora communis</i>	KWSACC002-2009	zebra	bushed grassland	S00°19'28.1	E036°55'54.3	2161
<i>Podospora communis</i>	KWSTE004-2009	zebra	Savannah	S03°02'29.7	E038°41'35.8	354
<i>Podospora communis</i>	KWSANP001-2009	giant forest hog	montane forest	S00°21'26.4	E036°51'23.8	2004
<i>Podospora communis</i>	KWSACC003-2009	giraffe	bushed grassland	S00°19'28.1	E036°55'54.3	2161
<i>Podospora communis</i>	KWSNNP006-2009	hippopotamus	Wetland	UTM370254976	M9850544	1877
<i>Podospora communis</i>	KWSNNP003-2009	impala	Grassland	UTM370252737	M9847748	1879
<i>Podospora communis</i>	KWSACC001-2009	impala	bushed grassland	S00°19'28.1	E036°55'54.3	2061
<i>Podospora communis</i>	KWSANP005-2009	waterbuck	montane forest	S00°20'23.2	E036°47'11.1	2075
<i>Podospora communis</i>	KWSTE006-2009	waterbuck	Riverine	S03°02'24.9	E038°42'57.1	343
<i>Podospora minor</i>	KWSACC002-2009	zebra	bushed grassland	S00°19'28.1	E036°55'54.3	2161

composed of *textura angularis* thick-walled brown elongated polygonal cells; second layer from outside made up of hyaline, thick-walled gelatinous polygonal cells; third layer of darker, thick-walled flattened cells; fourth layer composed of lighter thin-walled polygonal cells. *Paraphyses* exceeding the asci, filiform above and ventricose below, septate, 3–4.5 µm broad, hyaline. *Asci* 8-spored, 245–345 × 27.5–43 µm, cylindrical-clavate, unitunicate, narrow, evanescent, round apex, short stipitate. *Ascospores* uniseriate to biseriate, at first hyaline, single-celled, fusiform then cylindrical; spore head 37.5–47.5 × 20.5–25 µm at maturity, slightly inequilateral, black-brown, ellipsoidal to fusiform; germ pore apical; pedicel hyaline, cylindrical or clavate, broader at the tip; upper cauda longer and broader, 75.5–126.5 × 9–12 µm, lash-like, appearing striated and furrowed, eccentric, not covering the germ pore, hollow; lower cauda shorter and narrower, 46–73.5 × 4.5–5 µm, hyaline, hollow, attached to distal end of the pedicel, tips circinate.

Material examined – one specimen on dung incubated for 42 days – KENYA, Aberdare Country Club Game Sanctuary, Central Province, GPS S00°19'28.1" E036°55'54.3", altitude 2161m, zebra, 30 August 2009, P. Mungai, KWSACC002-2009.

Notes – *Podospora minor* is in the section *Podospora*. The ascospores of *P. minor* are morphologically similar to those of *P. fimiseda* (Ces. & De Not.) Niessl. belonging to the same section but are slightly smaller. The characters of *P. minor* seem to be intermediate between *P. appendiculata* (Auswer.) Niessl and *P. fimiseda*. This Kenyan collection has broader asci and larger ascospores in comparison to the specimen examined by Mirza & Cain (1969). This species appears to be rare in wildlife dung and we make the first record of *P. minor* in Kenya.

Ecology

Podospora communis (50%), *P. anserina* (25%) and *P. australis* (14.3%) are the most common on the dung types examined. (Adopted from Zak & Willig 2004)

Commonly collected (African elephant, black rhinoceros, zebra, Cape buffalo and giraffe) and rarely collected dung types (dikdik, hippopotamus, giant forest hog, impala and

waterbuck) were found in different habitat types, incubated and examined (Table 1).

Type, structure, texture, moisture contents and age of dung collected are important variables for coprophilous *Podospora*. The structure and composition of dung varies according to the animal species voiding it. The dung of African elephant is usually voided as one or two very coarse large randomly dispersed piles; black rhinoceros and hippopotamus dung are also large, less coarse and look very similar. However, black rhinoceros dung was always voided at one point.

Hippopotamus is territorial and thus usually marks its territory by splashing dung on vegetation within the territory and therefore its dung is always a mixture of several days voided biomass. The texture of Cape buffalo dung was the finest for the large mammals sampled. The rest of the wild animals sampled void dung in form of pellets of various shapes and sizes. Zebra has the largest pellets followed by giraffe while dikdik has the smallest dung pellets sampled.

Moisture content of the dung has a great influence on *Podospora* sporulation. Extremely wet dung samples such as those from the very rainy mountainous Aberdares National Park needs thorough air-drying after sampling. This was noted to have some influence on *Podospora* species occurrence.

The time the dung is exposed since voiding and the time it is sampled is also a crucial variable. Very old and dry dung does not yield as many isolates as freshly voided dung.

Dung sampled from grassland habitats produced the most *Podospora* isolates in this study (Table 1).

Conclusion

Coprophilous *Podospora* species diversity in Kenya is high and seems to be influenced by a number of factors both biotic and abiotic. The correlation observed between the structure of dung and type on one hand and *Podospora* on the other hand need further elucidation. This study has helped create awareness on the need to understand dung fungi and its ecological roles. It is hoped that there will be a shift in policy to embrace fauna,

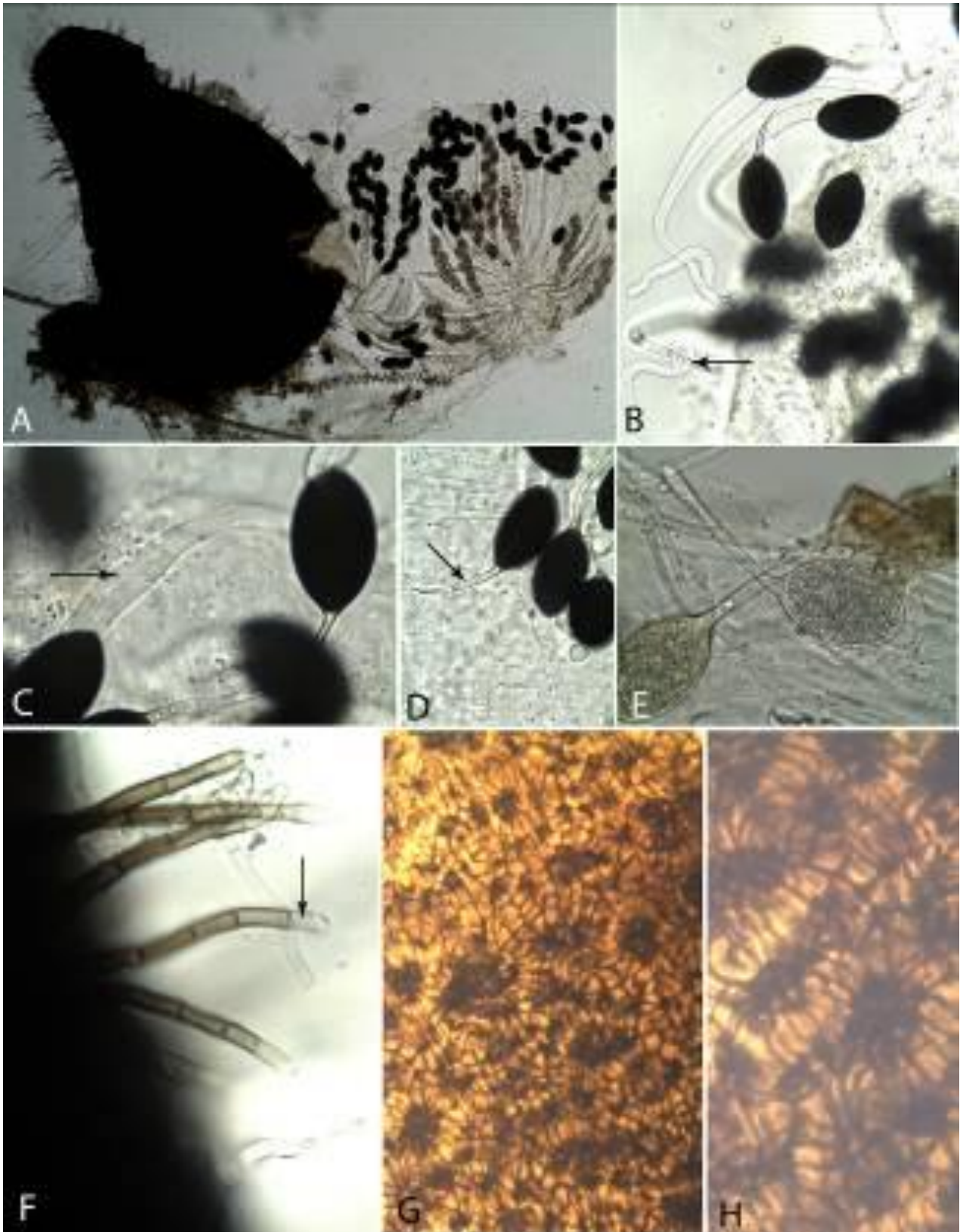


Fig. 9 – *Podospora minor* (KWSACC002-2009). **A** Squashed ascoma. **B** Ascospores showing caudae, note coiled ends (arrow). **C** Details of cauda, note the furrows (arrow). **D** Details of pedicel, note the curvature (arrow). **E** Immature ascospores. **F** Ascomatal hairs, note the hyaline tips. **G–H** Ascomatal wall. **Scale bars:** **A** = 200 μm , **B, G** = 50 μm , **C–F, H** = 20 μm .

flora and fungi (3Fs) as a new paradigm for Kenyan biodiversity conservation and management.

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