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Teodor T. Denchev, Cvetomir M. Denchev,
Muneo Michikawa & Makoto Kakishima

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(*Anthracoideaceae*) in Japan
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The genus *Anthracoidea* (*Anthracoideaceae*) in Japan and some adjacent regions

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Abstract. This study endeavors to clarify the taxonomy of *Anthracoidea* species occurring in East Asia. Being a cosmopolitan genus, more widely distributed in temperate and subarctic regions of the Northern Hemisphere, *Anthracoidea* is insufficiently studied in East Asia, particularly in Japan and Korea. A comprehensive account of the species composition and distribution of the *Anthracoidea* species in Japan is presented herein. Further, information about the *Anthracoidea* species in the Kuriles, Sakhalin, and Korean Peninsula is also provided. Three new smut fungi are described and illustrated as follows: *Anthracoidea caricis-grallatoriae* on *Carex grillatoria* from Japan, *Anthracoidea lanceolatae* on *Carex lanceolata* from South Korea, and *Anthracoidea pseudomichelii* on *Carex michelii* from Central Europe. For *Cintractia japonica* on ‘*Carex capillacea*’, a new combination, *Anthracoidea japonica*, is proposed. *Anthracoidea grillatoriae* Vánky is a superfluous name and a synonym of *A. japonica*. The existence of the type specimen of *Cintractia subglobosa* S. Ito makes the lectotypification of *C. subglobosa* redundant. Similarly, a lectotype of *Cintractia variabilis* S. Ito is also made redundant. Based on a comparative morphological investigation, 20 *Anthracoidea* species were established in Japan, all of them on host plants of *Carex*. In addition to *Anthracoidea caricis-grallatoriae*, six other species, *A. capillaris*, *A. humilis*, *A. irregularis*, *A. kariii*, *A. michelii*,

^aTeodor T. Denchev and Cvetomir M. Denchev have main contribution for the conduction of this study. Both of them contributed equally.

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and *A. sempervirentis*, are reported for the first time from Japan. Eight plant species are reported as new hosts of *Anthracoidea* species in Japan: *Carex gmelinii* with *Anthracoidea buxbaumii*; *Carex foliosissima*, *C. mitrata*, *C. morrowii*, *C. nervata*, and *C. subebracteata* with *Anthracoidea caryophylleae*; *Carex fernaldiana* and *C. tenuinervis* with *Anthracoidea microsora*. Ten fungus-host combinations, *Anthracoidea capillaris* on *Carex tenuiformis*, *A. caryophylleae* on *Carex leucochlora*, *A. caryophylleae* on *Carex mitrata*, *A. caryophylleae* on *Carex foliosissima*, *A. caryophylleae* on *Carex morrowii*, *A. humilis* on *Carex lanceolata*, *A. kariii* on *Carex omiana* var. *monticola*, *A. microsora* on *Carex fernaldiana*, *A. microsora* on *Carex tenuinervis*, and *A. sempervirentis* on *Carex makinoensis*, are new for science. Additional distribution records are given for some *Anthracoidea* species hitherto known from Japan. The genus *Anthracoidea* is recorded for the first time from the Korean Peninsula, with three species from South Korea: *A. caryophylleae* on *Carex leucochlora*, *A. lanceolatae* on *Carex lanceolata*, and *A. siderostictae* on *Carex siderosticta*. Two species, *Anthracoidea caryophylleae* and *A. variabilis*, are reported for the first time from the Kuriles. *Anthracoidea variabilis* is a new species for Russia. Three species, *Anthracoidea globularis*, *A. heterospora*, and *A. paniceae*, are reported for the first time from Sakhalin. The study further found that four fungus-host combinations had been wrongly recorded in the literature, specifically, *Carex cespitosa* is not a host of *Anthracoidea variabilis*; *Carex foliosissima* and *C. conica* are not hosts of *Anthracoidea microsora*; and *Carex tarumensis* is not a host of *Anthracoidea buxbaumii*.

Key words: *Anthracoidea*, *Anthracoideaceae*, *Carex*, Japan, Korea, Kuriles, Sakhalin, smut fungi

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Introduction

The genus *Anthracoidea* was established by Brefeld (1895) to comprise two species of ovariicolous smut fungi on *Carex*, *Ustilago caricis* (Pers.) Unger and *U. subinclusa* Körn., which possess (i) black sori, originally covered by a false membrane of fungal cells, hyphae, and fragments of host cells, (ii) spores that are formed directly on the outer surface of the sedge nut, and (iii) spores that germinate to produce a two-celled basidium (in the past called ‘promycelium’). Brefeld (1895) noted that *Anthracoidea* was morphologically very close to another genus, *Cintractia* Cornu (1883). The type species of this genus is *Cintractia axicola* (Berk.) Cornu on *Fimbristylis dichotoma*. It is characterized by sori surrounding the inflorescence axis, occasionally the flowers, and by a fungal stroma (a layer of sterile hyphae with sporogenous pockets in which the spores are formed) on the surface of the host tissue. The sorus is covered by a peridium, formed by sterile, gelatinized hyphae, which envelopes the spore mass (Cornu 1883; Thirumalachar & Whitehead 1975; Piepenbring 2000; Vánky 2002). Neither a sterile stroma nor hyphal strands are formed in the *Anthracoidea* sorus (Kukkonen 1963; Vánky 1979). Another distinction is the spore germination of *Cintractia axicola* results in a 4-celled phragmobasidium in which compatible cells conjugate in pairs and produce a large, dikaryotic conidium (Ingold 1995, 1999). Despite these differences, Magnus (1896) placed *Anthracoidea caricis* and *A. subinclusa* in *Cintractia*. The name *Anthracoidea* has long been considered a synonym of *Cintractia*. *Cintractia caricis* has been long used in a very broad sense with a wide host range and geographical distribution (e.g. in Ciferri 1938; Liro 1938; Fischer 1953; Zundel 1953; Săvulescu 1957; Ulyanishchev 1968; Hirschhorn 1986).

The genus *Anthracoidea* was re-established by Kukkonen (1963). Zambettakis (1978) attempted a critical revision of *Anthracoidea* but his species delimitation was not adopted by the most mycologists (for criticism of this monograph, see Nannfeldt 1979: 39). At the same time, Kukkonen’s (1963) concept was applied and further developed by Nannfeldt (1979) and Vánky (1979, 1985a, 1994).

The species of *Anthracoidea* are host-specific parasites of cyperaceous plants as a result of homothallism and parallel evolution with their hosts (Kukkonen 1963; Vánky 1979). *Anthracoidea* species were considered by Vánky (1979) to be restricted to host plants in the same or closely related sections of *Carex*.

The first comprehensive treatment of all known species of *Anthracoidea* was recently proposed by Vánky (2011a). He recognized 97 species of *Anthracoidea* distributed on members of *Carex*, *Carpha*, *Fuirena*, *Kobresia*, *Schoenus*, *Scirpus*, and *Uncinia*. Articles with description of new *Anthracoidea* species (from Asia and North America) or contributions to rare species were recently published by Denchev & Denchev (2011a, b, 2013), Denchev et al. (2011a, b, c), He et al. (2011), Vánky (2011b), Vánky & Salo (2011), Piaček (2012), Vánky & Abbasi (2012, 2013), and Savchenko et al. (2013).

Currently, we recognize 106 species of *Anthracoidea*. Three new species (from Japan, South Korea, and Central Europe) are additionally proposed in this work.

Traditionally, *Anthracoidea* species were classified in *Ustilaginaceae* (comp. Vánky 1985a). Denchev (1997) described a new family, *Anthracoideaceae*, for the genera *Anthracoidea* and *Planetella* based on basidial morphology, i.e., the presence of two-celled aerial basidium, which is a unique type of spore germination not seen in other smut fungi. As a result of

Fig. 1. Map of the study area (the Ryukyu Archipelago is omitted because of lack of *Anthracoidea* records from there).

molecular phylogenetic studies (Begerow et al. 2006), additional genera were transferred to the *Anthracoideaceae*, and the delimitation of that family was widened, currently including 20 genera of smut fungi on host plants in *Cyperaceae* and *Juncaceae* (Vánky 2011).

Study area and a short history of research on the *Anthracoidea* in that region

The present taxonomic study focuses on *Anthracoidea* species in Japan and some adjacent regions (the Kuriles, Sakhalin Island, and the Korean Peninsula) (Fig. 1). The revision of this genus was prompted by the lack of contemporary taxonomic studies of *Anthracoidea* in Japan. This work also forms part of an ongoing preparation of a monograph of the smut fungi in Japan. All specimens of smut fungi that were available at the main Japanese dried reference collections were examined. Among the studied specimens, especially among these kept at SAPA, there are smut fungi from the Kuriles and Sakhalin, collected by Japanese mycologists. It seems that some of these specimens were not seen by the Russian mycologists who studied the taxonomy of the smut fungi of the Far East of Russia (e.g. Azbukina & Khavkina 1984; Karatygin & Azbukina 1989; Govorova 1990; Azbukina et al. 1995). Consequently, we decided also to include information about the *Anthracoidea* species in the Kuriles and Sakhalin, both published and obtained from our examination of Japanese dried reference collections.

In the course of our study, species of *Anthracoidea* were recorded from the Korean Peninsula for the first time. We considered that it would be useful for these findings from a neighbouring region be included in this study.

The first Japanese records of *Cintractia* species on *Carex* were published by Sydow & Sydow (1909, 1913) who reported *C. caricis* on *Carex capillacea* (for information about the determination of the correct name of the host plant, see the comments under *Anthracoidea japonica* in this treatment), and on *Carex pediformis*, respectively. Sydow (1924) described from Japan two *Cintractia* species: *C. microsora* on *Carex* ‘*remota*’, which was transferred by Kukkonen (1964) to *Anthracoidea*, and *C. japonica* on *Carex* ‘*capillacea*’. Ito (1935) described other two species: *Cintractia subglobosa* on *Carex limosa*, and *Cintractia variabilis* on *Carex arenicola*. One year later, S. Ito published the first monograph of the smut fungi in Japan (Ito 1936). Four species of *Cintractia*, which are all currently recognized as members of *Anthracoidea*, on *Carex* (*C. caricis*, *C. subglobosa*, *C. subinclusa*, and *C. variabilis*) were included in that monograph. Togashi & Maki (1940) described *Cintractia obovoidea*, which later was transferred to *Anthracoidea*, as *A. obovoidea* (Kakishima 1982). In fact, *Anthracoidea obovoidea* belongs to *Farysia* (see later comments). Nannfeldt (1979) reported *Anthracoidea globularis* as distributed in Japan but without citing any specimen or particular literature source. In the rubric about the general distribution of *Anthracoidea irregularis*, Nannfeldt (1979: 25) noted that ‘*Carex pediformis* is known smutted only from Fennoscandia and Japan’ but did not indicate that he had seen a Japanese specimen (see later comments). A third species, distributed in Japan, was discussed by Nannfeldt (1979). He attributed the paratype of *Cintractia subglobosa* (on *Carex buxbaumii*) to *Anthracoidea buxbaumii* without seeing a specimen (as assumed by Vánky & Harada 1990: 448) and based only on its host specificity. Five records of *Cintractia caricis* on three host plants from Kyushu were reported by Hirata & Yuji (1979).

In 1982, a second monograph of the smut fungi in Japan was published by M. Kakishima in which six species of *Anthracoidea* were accepted, namely: *A. buxbaumii*, *A. caricis*, *A. microsora*, *A. obovoidea*, *A. subinclusa* (on *Carex siderosticta*), and *A. variabilis*. As discussed below in the taxonomic part, the correct name for the smut fungus on *Carex siderosticta* is *Anthracoidea siderostictae*.

Harada (1983) correctly identified *Anthracoidea subinclusa* on *Carex miyabei* (as *C. fedia* var. *miyabei*) for the first time in Japan. Based on specimens at SAPA and TSH, Vánky & Harada (1990) recorded three species as new for Japan, namely, *Anthracoidea caryophylleae*, *A. limosa*, and *A. pilosae*. Further, Vánky (1995) described *Anthracoidea grallatoriae* on *Carex grallatoria* (for its current status, see later comments). Katumoto (2010) compiled a list of ten *Anthracoidea* species in Japan, but did not critically examine specimens. Recently, two new species, *Anthracoidea blepharicarpae* on *Carex blepharicarpa*, and *Anthracoidea dispalatae* on *Carex dispalata*, were described from Japan by Denchev et al. (2011c).

Currently, thirteen species of *Anthracoidea* (including the two species described by Denchev et al. 2011c) are known from Japan: *A. blepharicarpae*, *A. buxbaumii*, *A. caricis*, *A. caryophylleae*, *A. dispalatae*, *A. globularis*, *A. limosa*, *A. microsora*, *A. pilosae*, *A. siderostictae*, *A. subinclusa*, *A. variabilis*, and *Cintractia japonica* (incl. *A. grallatoriae*).

Information about *Anthracoidea* species (in part, as *Cintractia* species) from the Kuriles and Sakhalin is given by Kawai & Ôtani (1931), Ito (1935, 1936), Azbukina & Khavkina (1984), Govorova (1987, 1990), Karatygin & Azbukina (1989), Vánky & Harada (1990), Azbukina et al. (1995), and Denchev et al. (2011a).

The smut fungi on wild plants in the Korean Peninsula are poorly known. A list of the known species, together with four new records, was given by Denchev et al. (2007a). Additional data were published by Denchev & Kakishima (2007), Denchev et al. (2007b), and Park et al. (2010). Until the beginning of this study, there were no records of *Anthracoidea* from the Korean Peninsula.

Materials and methods

This study is based on examination of specimens from the following dried reference collections:

- Japan: **HHUF** – Faculty of Agriculture and Life Sciences, Hirosaki University, Hirosaki; **SAPA** – Faculty of Agriculture, Hokkaido University, Sapporo; **TNS-F** – Department of Botany, National Museum of Nature and Science, Tsukuba; **TSH** – Laboratory of Plant Parasitic Mycology, Faculty of Life and Environmental Sciences, University of Tsukuba, Tsukuba;
- Korea: **SNU** – College of Natural Sciences, Seoul National University, Seoul; **SNUA** – T.B. Lee Herbarium, College of Agriculture and Life Sciences, Seoul National University, Seoul; **SWU** – Sungshin Women's University Herbarium, Seoul;
- Other countries: **DAOM** – National Mycological Herbarium, Agriculture and Agri-Food Canada; **H.U.V.** – Herbarium Ustilaginales Vánky, Tübingen, Germany (a personal collection of Dr K. Vánky); **K** – Royal Botanic Gardens, Kew, UK; **SOMF** – Mycological Collection, Institute of Biodiversity and Ecosystem Research, Sofia, Bulgaria.

Japanese specimens collected by C.M. Denchev in 1999, which have not yet been deposited in a public collection, are cited without an acronym. The total number of specimens revised by us is 108.

Specimens were examined solely by classical comparative morphology, as most were considered too old to yield DNA for molecular phylogenetic analysis.

Initially, sori were examined with a low power dissecting microscope. For LM observations, spores were mounted in lactophenol solution on glass slides, gently heated to boiling point to rehydrate the spores, and then cooled. Spore measurements are given in the form: min–max (extreme values, if necessary) [mean $\pm$ 1 standard deviation]. The total number of spores (n) from all collections (x) measured are given in the form '(n/x)'. For SEM, spores were attached to specimen holders by double-sided adhesive tape and coated with gold with an ion sputter. The surface structure of spores was observed at 10 kV accelerating voltage and photographed with a JEOL JSM-5510 scanning electron microscope.

The basic spore shape in *Anthracoidea* is necessary to be appreciated as flattened. The spore shape was described as seen in plane view. Because of the variability in a single specimen, at least 50 spores were measured from each slide. Spore measurements include

the surface ornamentations. The following spore features have diagnostic value: spore shape; presence of protuberances; range and mean ± 1 SD of spore length, range and mean ± 1 SD of spore width; spore thickness; presence of a gelatinous sheath; wall thickness, uniformity of the wall thickness within a single spore; presence of internal swellings of the wall; presence of light-refractive areas on the wall; type of spore ornamentation; arrangement of the warts (e.g. fusion, formation of rows, presence of small warts on the wall surface between the main warts); effect of surface ornamentation on the spore profile; spore germination (if studied).

The internal wall swellings, when present, are visible as circular dark spots in plane view (Figs 2a, b). They are formed by local swellings of the endosporium or the exosporium (Piepenbring et al. 1998). It is important their presence/absence to be recorded, as well as their number when present. Internal wall swellings are difficult to observe in dark coloured spores and/or thick walls. Not all circular dark spots visible in LM are internal wall swellings, as some may have resulted from overlapping spores or broken fragments of other spores situated beneath the observed spore. For spores with angular shape, an angle or protuberance, situated on the opposite side of the observed spore, may cause a spot.

Some *Anthracoidea* species have spore walls with protuberances (Fig. 2d). Another structure, characteristic for the spore wall surface of these species, is a light-refractive area (or local thickening of a persistent part of the sheath – Piepenbring et al. 1998) (Fig. 2c). The presence and frequency of protuberances and light-refractive areas on the wall surface have diagnostic value.

The patterns of spore wall ornamentation are of special value in the taxonomy of smut fungi. Unfortunately, most authors have inconsistently described spore wall ornamentation, even in the same treatment. For example, it is often difficult to interpret the use of the terms punctate, verrucose, verruculose, tuberculate, and echinate in species descriptions since usually there is no glossary of terms.

Different systems have been proposed for classifying the patterns of spore wall ornamentation, e.g., Zambettakis (1970) with 23 types; Kakishima (1980) with 11 types; Govorova & Azbukina (1986) with 8 types; Vánky (1991) with 13 types. For instance, punctate and smooth walls were considered together as 'smooth to very slightly punctate' by Kakishima (1980) or as having projections which were 'barely visible and measure 0.1–0.3 μm ', not influencing the spore profile by Vánky (1991). Kakishima (1980) recognized two types of ornamentation with warts (minutely verrucose, with warts 'less than 0.2 μm in height', and verrucose, with warts 'about 0.2–0.4 μm in height'). Kakishima's (1980) classification is based mainly on observations of Japanese specimens of smut fungi and because of this reason, cases of warts higher than 0.4 μm are not considered by him. Vánky (1991) described all spores with warts as verrucose, and defined the verrucae as 'rounded ornamentations ranging between 0.3–1 μm ', 'clearly visible, causing the spore profile to be very finely wavy to finely serrulate'. Govorova & Azbukina (1986) defined the wart as a projection with a diameter at the base that is smaller than or equal to the height, and divided the verrucose type into three subtypes on the basis of the height of warts, i.e., 0.1–0.3 μm , 0.3–0.6 μm , and 0.6–0.9 μm . A projection with a larger diameter at the base than the height was considered by Govorova & Azbukina (1986) as a tuberculum. Unfortunately,

Fig. 2. Spore wall features: **a, b** – internal swellings (**a** – *A. japonica* on *Carex grallatoria*, SA-PA, sine num., holotype; **b** – *A. capillaris* on *Carex tenuiformis*, K, sine num., M. Furuse, no. 22 648), **c** – light-refractive areas (*A. irregularis* on *Carex lanceolata*, Mt. Nantaisan, June 1999, C.M. Denchev), **d** – protuberance (*A. irregularis* on *Carex lanceolata*, Mt. Nantaisan, June 1999, C.M. Denchev). Spores viewed with LM. Scale bars = 10 μ m

the proportions for a wart suggested by them are not applicable in all cases, i.e. sometimes the wart length at the base is larger than the height (compare for instance proportions of warts given by Kukkonen (1963) for some *Anthracoidea* species).

The height of the projection and the shape of its apex are best observed in SEM, along the edge of the spore.

While the notion of a smooth spore does not need explanation, punctate is a term with a different interpretation. The definition of punctate by Kirk et al. (2008: Fig. 20.5) is not applicable to the spores of smut fungi, as their figure illustrates a verrucose or tuberculate (depends on the scale) ornamentation. A **punctate** (dotted) surface is very well described by Stearn (1998: 327) as 'covered by minute impressions, as if made by the point of a pin'. Other basic ornaments of spore wall ornamentations, which have different interpretations, are wart, tuberculum, and spine. The **wart** (Lat., *verruca*) is more or less regular projection with a rounded apex while the **spine** (or **spinule**) is a pointed projection of the echinate (or echinulate, respectively) type. The **tuberculum** is a wart-like projection, used as a term when the ornament is large (more than 1 μm at the base) and coarse, e.g., in the spore ornamentation of *Entorrhiza casparyana*, *E. aschersoniana*, *Entyloma verruculosum*.

In the *Anthracoidea* species, the most common ornament is the wart. In this genus, smooth spores are rarely observed. The following types of ornamentation may be seen in SEM:

smooth

punctate – with very low projections, up to 0.1 μm high

verrucose – with warts

- **minutely verruculose** – with warts 0.1–0.3 μm high
- **moderately verruculose** – with warts 0.3–0.5 μm high
- **verrucose** – with warts higher than 0.5 μm

coarsely verrucose – with large, irregular projections, higher than 0.5 μm (up to 2 μm high), apically flattened and slightly enlarged, densely situated, regularly or irregularly arranged.

Coarsely verrucose ornamentation is characteristic of a group of *Anthracoidea* species, usually described as 'echinate', e.g., *A. intercedens* Nannf. (see Denchev & Minter 2011b) and *A. subinclusa*.

The effect of the ornaments on the spore profile (when viewed in LM with 1000 $\times$ magnification) is also informative but the attempts of some authors to describe this effect with terms such as 'finely wavy to finely serrulate' is very subjective. For this reason, we describe the effect of the ornaments on the spore profile under light microscopy as 'smooth to slightly affected' or 'affecting the spore profile'.

The reliability of the identification of the plant hosts is perhaps the most important problem in any revision of parasitic fungi, especially if specimens are old. In this study, the majority of the host plants were revised by one of the authors of this work (M. Michikawa). If the host plant is revised, it is designated by '(pl. rev.)'.

The Japanese specimens of each species treated are listed by island and prefecture from north to south and west to east.

The general distribution of the fungal species is based on numerous sources: Ito (1935, 1936), Liro (1934, 1935, 1938), Lindtner (1950), Savile (1952), Nannfeldt & Lindeberg

(1957, 1965), Săvulescu (1957), Boidol & Poelt (1963), Kukkonen (1963, 1964), Gremmen & Parmelee (1972), Nannfeldt (1977, 1979), Braun & Hirsch (1978), Vánky (1979, 1983, 1985a, b, 1994, 1995, 2005a, b, 2011a), Hirsch & Braun (1980), Kakishima (1982), Karatygin (1982), Harada (1983), Karatygin et al. (1983, 1990, 1999), Parmelee (1983, 1988), Azbukina & Khavkina (1984), Mordue & Ainsworth (1984), Karatygin & Simonyan (1985), Zogg (1986), Govorova (1987, 1990), Ramazanov et al. (1987), Scholz & Scholz (1988, 2000, 2005), Guo & Xi (1989), Karatygin & Azbukina (1989), Dörfelt & Täglic (1990), Vánky & Harada (1990), Harmaja (1991), Guo (1994, 1996, 2000, 2004, 2006, 2007, 2011), Azbukina et al. (1995), Foitzik (1996), Almaraz & Durrieu (1997), Paulech et al. (1997), Almaraz (1998, 2002), Bolay (1998), Paulech (1998), Braun (1999), Hardtke & Otto (1999), Müller (2000), Denchev (2001), Ignatavičiūtė (2001), Chlebicki (2002), Ershad & Amini Rad (2003, 2004), Scholler et al. (2003), Guo & Zhang (2004), Helgi Hallgrímsson & Guðríður Gyða Eyjólfsdóttir (2004), Kokeš & Müller (2004), Zhang & Guo (2004), Zwetko & Blanz (2004), Piątek et al. (2005), Spooner & Legon (2006), Kemler et al. (2007), Vánky & Shivas (2008), Lutz & Vánky (2009), Piątek & Mułenko (2010), Denchev & Minter (2010a, b, c, d, e, 2011a, c, d, e, f, g, h, i), Denchev et al. (2011a, c), Savchenko & Heluta (2012), Denchev & Denchev (2013), Vánky & Abbasi (2013), etc.

The general distribution of the host plants is based mainly on Egorova (1999), Govaerts et al. (2007), Dai et al. (2010), and Hoshino et al. (2011).

Taxonomic treatment

Anthracoidea Bref., Untersuchungen aus dem Gesamtgebiete der Mykologi 12: 143, 1895. — *Cintractia* sensu ampl. Magnus, Verhandlungen des Botanischen Vereins der Provinz Brandenburg und die Angrenzenden Lander 37: 78, 1896, non *Cintractia* Cornu, Annales des Sciences Naturelles, Botanique, Sér. 6, 15: 279, 1883 (sensu str. orig.).

Cintractiomyxa Golovin, Botanicheskie Materialy Otdela Sporovyh Rastenii Botanicheskogo Instituta Imeni V.L. Komarova Akademii Nauk S.S.S.R. 8: 108, 1952.

Sori in and around ovaries of cyperaceous plants (in the cases of *Carex* – scattered in female spikes or in female flowers of mixed spikes, replacing the ovaries), usually partly hidden by the glumes; as globose, subglobose, broadly ellipsoidal or ovoid, rarely ellipsoidal, black, hard bodies; composed of the remainder of the nut in the center and a spore mass around it (spore formation on the outer surface of the nut); originally covered by a thin, white, greyish or silvery, false membrane of fungal cells, hyphae, and fragments of host cells, which ruptures exposing the spore mass. **Spore mass** initially firmly agglutinated, later powdery or semi-agglutinated on the surface, less often mature sori agglutinated on the surface and breaking into small, irregular pieces; composed only of teliospores, sterile cells absent. **Spores** formed singly, often flattened, in plane view more or less regular in outline (orbicular, suborbicular or broadly elliptical) or more or less irregular, relatively large (compared to the spores of other genera of smut fungi); surrounded by a gelatinous sheath that breaks down at maturity (sometimes mature spores with remnants of that gelatinous sheath). Spore wall unevenly or evenly thickened; rarely with pale, thinner-walled polar regions; with or without protuberances, often with internal swellings and/or light-refractive

areas, usually ornamented with warts, rarely punctate or smooth, few species with coarse (up to 2 μm high), irregular ornaments, apically flattened and slightly enlarged. **Spore germination** results in a two-celled aerial basidium forming one or more basidiospores on each cell; basidiospores globose, subglobose, ovoid or cylindrical. **Anamorph** present in some species. **Host-parasite interaction** (Vánky 2011a) by intracellular hyphae, coated by an electron-opaque matrix. Mature septa poreless.

Type: *Anthracoidea caricis* (Pers.) Bref.

Initially, the sori are covered by a thin membrane. Mature teliospores are liberated and dispersed by wind after the membrane ruptures. At an early stage of plant flowering, spores germinate, produce basidiospores, and infect flowers. The infection is local, floral (confined to individual flowers). Hyphae are localized in the ovaries and walls of single nuts. The spores are produced on the outer nut surface (Kukkonen 1963; Kukkonen & Vatanen 1968; Vánky 2002). Infected flowers do not form seeds as the ovaries are destroyed.

Based on the type of spore germination, the genus *Anthracoidea* is divided into two subgenera. *Anthracoidea* subgen. *Anthracoidea* is characterized by small to medium-sized spores (13–25 μm long) and globose, subglobose or ovoid basidiospores, up to 30 μm long, several produced per basidial cell. *Anthracoidea* subgen. *Procetes* Kukkonen is characterized by medium to large spores (22–37 μm long) and cylindrical basidiospores, 40–90 μm long, only one produced per basidial cell (Kukkonen 1963; Vánky 2011a). Unfortunately, the type of spore germination is known only for some of the species, making it difficult to refer all of the species to a subgenus.

The genus *Anthracoidea* comprises 109 species (including three species, described in this treatment). It is a cosmopolitan genus, more widely distributed in temperate and subarctic regions of the Northern Hemisphere.

Key to the *Anthracoidea* species distributed in Japan, the Kuriles, Sakhalin, and the Korean Peninsula, based on host plant taxonomy (arranged in sections)

The host plants that occur in the area studied in this treatment are given in square brackets.

On *Carex* subgen. *Carex*

On sect. *Acrocystis* (*Montanae*)

1 Spore wall with low warts, up to 0.2 μm high. [Currently known on *C. globularis*] *A. globularis*

1* Spore wall with warts 0.2–0.3 μm (in the neotype on *C. pilulifera*, up to 0.4 μm) high. [Currently known on *C. oxyandra*, (?) *C. vanheurckii*] *A. caricis*

On sect. *Anomalae*. Currently known on *C. dispalata* *A. dispalatae*

On sect. *Aulocystis* (*Frigidae*)

1 Spores mostly rounded; spore wall mostly even, up to 1.5 μm thick. [Currently known on *C. stenantha* var. *taisetsuensis*] *A. misandreae*

1* Spores mostly irregular or angular; spore wall unevenly thickened, 1.6–3.4 μm thick, thickest at the angles. [Currently known on *C. makinoensis*] *A. sempervirentis*

On sect. *Carex*. Currently known on *C. miyabei* *A. subinclusa*

On sect. *Chlorostachyae*. Currently known on *C. capillaris*, *C. tenuiformis* . . *A. capillaris*

On sect. *Depauperatae*

1 Light-refractive areas common, often abundant; spores mostly irregular and angular . . 2

1* Light-refractive areas usually absent; spores more regular, suborbicular, broadly elliptic or irregular in outline, 20.5–28(–30) μm long. [Currently known on *C. pilosa*] . . *A. pilosae*

2 Spores 16–24 μm long; elongated and irregular spores with length exceeding 26 μm absent; length mean : width mean ratio = 1.18–1.21. [Currently known on *C. longirostrata*] *A. michelii*

2* Spores 16–29(–34) μm long; elongated and irregular spores, with length up to 34 μm present; length mean : width mean ratio = 1.32. [Currently known only from Central Europe, on *C. michelii*] [*A. pseudomichelii*]

On sect. *Digitatae*

1 Spores distinctly irregular, often irregularly angular or elongated, up to 29(–32) μm long, with numerous and conspicuous protuberances, often with well-developed light-refractive areas. [Currently known on *C. lanceolata*] *A. irregularis*

1* Spores more regular, elongated spores absent; smaller (up to 25(–26.5) μm long), rarely with protuberances 2

2 Spore warts 0.2–0.4 μm high, sometimes ca 0.5 μm high and affecting the spore profile; sometimes with light-refractive areas. [Currently known on *C. lanceolata*] . . *A. humilis*

2* Spore warts 0.5–0.8 μm high, always affecting the spore profile; light-refractive areas absent. [Currently known on *C. lanceolata*] *A. lanceolatae*

On sect. *Grallatoriae*

1 Spores 21.5–36.5(–38) μm long, spore wall 1.5–3.5 μm thick. [Currently known on *C. grallatoria*] *A. japonica*

1* Spores (19.5–)20–26(–27) μm long, spore wall 0.9–1.6(–1.9) μm thick. [Currently known on *C. grallatoria*] *A. caricis-grallatoriae*

On sect. *Limosae*. Currently known on *C. limosa*, *C. rariflora* *A. limosa*

On sect. *Mitratae*

1 Spores 18–30(–34) μm long, spore mean length more than 22.5 μm . [Currently known on *C. blepharicarpa*] *A. blepharicarpa*

1* Spores (14–)16–25(–26.5) μm long, spore mean length less than 21.5 μm 2

2 Spores minutely to moderately verruculose, warts 0.2–0.4 μm high, punctate between the warts; profile smooth or nearly so. [Currently known on *C. foliosissima*, *C. leucochlora*, *C. microtricha*, *C. mitrata* var. *aristata*, *C. morrowii*, *C. nervata*, *C. subebracteata*] *A. caryophylleae*

- 2* Spores moderately verruculose to verrucose, warts 0.4–0.6 μm high, affecting the spore profile. [Currently known on *C. alterniflora* var. *alterniflora*, *C. duvaliana*, *C. fernaldiana*, *C. stenostachys* var. *cuneata*, *C. stenostachys* s. lat., *C. tenuinervis* *A. microsora*

On sect. *Paniceae*

- 1 Spores usually with 1–3 internal swellings. [Currently known on *C. laxa*] . . . *A. laxae*

- 1* Internal swellings hardly visible. [Currently known on *C. livida*, *C. vaginata* var. *vaginata*, *C. vaginata* var. *petersii*] *A. paniceae*

- On sect. *Phacocystis* (*Acutae*). Currently known on *C. cespitosa* *A. heterospora*

- On sect. *Racemosae*. Currently known on *C. buxbaumii*, *C. gmelinii* *A. buxbaumii*

- On sect. *Scitae*. Currently known on *C. flavocuspis* subsp. *krascheninnikovii*, *C. nesophila*, *C. podocarpa* *A. atratae*

- On sect. *Siderostictae*. Currently known on *C. ciliatomarginata*, *C. siderosticta*
. *A. siderostictae*

- On sect. *Silvaticae*. Currently known on *C. arnellii* *A. arnellii*

- On sect. *Temnemis*. Currently known on *C. middendorffii* *A. liroi*

- On sect. *Vesicariae*. Currently known on *C. saxatilis* *A. subinclusa*

On *Carex* subgen. *Vignea*

- On sect. *Divisae*. Currently known on *C. arenicola* *A. variabilis*

- On sect. *Stellulatae*. Currently known on *C. omiana* var. *omiana*, *C. omiana* var. *monticola*
. *A. kariii*

On *Kobresia*

- On sect. *Elyna*. Currently known on *Kobresia myosuroides* *A. elynae*

On *Carex* subgen. *Carex*

On sect. *Acrocystis* (*Montanae*)

Anthracoidea caricis (Pers. : Pers.) Bref., Untersuchungen aus dem Gesamtgebiete der Mykologie, 12, Brandpilze 3: 144, 1895. — *Uredo caricis* Pers. : Pers., Synopsis Methodica Fungorum 1: 225, 1801. — *Caeoma caricis* (Pers. : Pers.) Link, in Willdenow, Linné's Species Plantarum, 4th edn, 6(2): 5, 1825. — *Ustilago caricis* (Pers. : Pers.) Unger, Ueber den Einfluss des Bodens: 211, 1836. — *Cintractia caricis* (Pers. : Pers.) Magnus, Verhandlungen des Botanischen Vereins der Provinz Brandenburg 37[1895]: 78, 1896. — Neotype on *Carex pilulifera*, Germany, Brandenburg, Kreis Zauch-Belzig, between Beelitz and Schlunkendorf, 10 Jun 1935, E. Fahrenhorff (TUR!) (design. by Kukkonen 1963: 58); isoneotypes in Sydow, Mycoth. germ., no. 2880 (as *Cintractia caricis*). Figs 5–8

Sori in ovaries, scattered in the inflorescence, as globose, subglobose or ovoid, black, hard bodies, 1–1.5 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view irregular, suborbicular or broadly elliptical in outline, sometimes with protuberances, in plane view $17.5\text{--}25\text{--}(26) \times 16.5\text{--}21.5$ ($21.8 \pm 1.8 \times 18.6 \pm 1.4$) μm ($n/2 = 100$), in side view $11\text{--}14.5$ μm thick, middle to dark reddish brown; wall unevenly thickened, $1.3\text{--}3\text{--}(4)$ μm thick, thickest at the angles and protuberances, sometimes with light-refractive areas and 1–3 internal swellings, minutely verruculose, warts $0.2\text{--}0.3$ μm high, spore profile smooth to slightly affected. In SEM warts partly fused and often arranged into short rows. **Spore germination** of *Anthracoidea*-type (Kukkonen 1963), resulting in a two-celled basidium, $100\text{--}150$ μm long, the apical cell $20\text{--}45$ μm long and $3.5\text{--}5.5$ μm thick; producing 2–3 basidiospores on each cell; basidiospores ellipsoidal or ovoid to obovoid, $6\text{--}14 \times 3.5\text{--}5.5$ μm .

Hosts — On *Cyperaceae*: *Carex* sect. *Acrocystis*: *Carex oxyandra* (Franch. & Sav.) Kudô, [(?) *Carex vanheurckii* Müll. Arg.].

Distribution within the studied area — On *C. oxyandra*, Japan (Hokkaido). [(?) On *C. vanheurckii*, North Kuriles (Shumshu)].

Specimens examined.

On *Carex oxyandra* (Franch. & Sav.) Kudô:

Japan: Hokkaido, Kushiro-shi, Mt. Oakan, 21 Aug 1926, leg. N. Hiratsuka (TSH, sine num.) (pl. rev.).

Japan: Hokkaido, Sapporo-shi, Mt. Saoro-dake, 19 Jul 1926, leg. N. Hiratsuka (TSH, sine num.) (pl. rev.).

[**Literature records:** on *Carex vanheurckii*, North Kuriles – Shumshu (Govorova 1990; Azbukina et al. 1995 – as *A. caryophylleae*) (specimens not seen; we assume that this plant species is a host of *A. caricis* – see the respective comments given to *A. caryophylleae*)].

Known hosts — On *Cyperaceae*: *Carex* sect. *Acrocystis*: *Carex amgunensis* F. Schmidt, *C. deflexa* Hornem., *C. inops* subsp. *heliophila* (Mack.) Crins, *C. montana* L., *C. oxyandra*, *C. peckii* Howe, *C. pensylvanica* Lam., *C. pilulifera* L., *C. rossii* Boott, *C. umbellata* Schkuhr ex Willd. (*C. abdita* Bickn.), [(?) *Carex vanheurckii*]; *Carex* sect. *Hallerianae*: *Carex halleriana* Asso.

General distribution. **Asia:** Japan, Mongolia, Russia (the Far East). **Europe:** Andora, Austria, Bosnia & Herzegovina, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Iceland, Italy, Lithuania, Norway, Poland, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, UK, Ukraine. **North America:** Canada, USA, Greenland.

Comments — *Anthracoidea caricis* is the type species of its genus. Initially, this species (as *Cintractia caricis*) was generally considered to have a wide host range, including a large number of species of *Carex* (comp. Zundel 1953). Later, it was recognized as a collective species (including *Cintractia irregularis* Liro) that was parasitic on sedges in two sections, *Acrocystis* and *Digitatae* (Kukkonen 1963: 59). *Cintractia irregularis* was recognized by Boidol & Poelt (1963) as a distinct species and transferred to *Anthracoidea*. Nannfeldt (1979) reduced the host range of *A. caricis* to sedges of section *Acrocystis*.

Vánky (1994: 39) suggested that *Carex halleriana* (section *Hallerianae*) must be added to the list of hosts but a specimen of *Anthracoidea* on *Carex halleriana* (Bulgaria, Stara Planina Mts, Beledie Han, 21 May 1991, leg. D. Stoyanov, SOMF 20 359), studied by us, is rather *A. irregularis*. The smut fungus on *Carex halleriana* deserves further study.

Species of *Carex* section *Digitatae*, *C. laeta*, *C. lanceolata*, *C. pediformis*, *C. rhizina* subsp. *rhizina*, and *C. rhizina* subsp. *reventa* (as *C. reventa*), were again treated as hosts of *A. caricis* by Guo (2000: 17) but these records need additional examination. Apparently, *A. caricis* does not infect sedges of section *Digitatae*. For this reason, China is not included here in the general distribution of *A. caricis*.

Based on observations made by Kukkonen (1963: 60), the North American specimens of *A. caricis* seem to be different from the European specimens by having more regular spores with thinner and evenly thickened walls and weakly developed light-refractive areas.

The **neotype** of *A. caricis* on *Carex pilulifera* was designated by Kukkonen (1963: 58) due to the lack of suitable material in Persoon's Herbarium in Leiden (L). It was studied by us and compared with the Japanese specimens, reported here. For the spores of the neotype, the following description is given:

Spores flattened, in plane view irregular to subpolygonal in outline, sometimes with protuberances, in plane view $16-25(-27) \times 14-20.5$ ($21.0 \pm 2.0 \times 17.2 \pm 1.7$) μm ($n = 100$), in side view $11-14$ μm thick, middle to dark reddish brown; wall unevenly thickened, $1.5-4$ μm thick, thickest at the angles and protuberances, light-refractive areas present, sometimes with 1–2 indistinct internal swellings, minutely to moderately verruculose, warts $0.2-0.4$ μm high, sometimes the spore profile is slightly affected. In SEM warts partly fused and arranged into short rows.

Figs 9–12

The Japanese specimens match this description.

Vánky (2011a) considered the presence of light-refractive areas as diagnostically useful for separating *A. caricis* from *A. globularis* and used it in the key to *Anthracoidea* species on sedges from sect. *Acrocystis*. However, light-refractive areas are present in the type specimen of *A. caricis*, as opposed to the statements of Nannfeldt (1979: 17) and Vánky (1994: 26, 2011: 26) who accepted them as rare or uncommon to lacking, respectively. The group of *Anthracoidea* species on sedges from sect. *Acrocystis* is in urgent need of revision, especially, the *Anthracoidea* specimens on American host plants.

Carex pilulifera is distributed in Europe, Macaronesia, and Morocco while *C. montana* is a Eurasiatic species; with smutted plants reported from Europe.

Carex amgunensis is distributed from the European part of Russia to the Far East of Russia, Mongolia, and North China; with smutted plants known from Mongolia (Dörfelt & Täglich 1990; Braun 1999) and the Far East of Russia (as *A. caryophylleae*, Govorova 1990).

Carex oxyandra is with an Eastern Asiatic distribution. It occurs in Far East of Russia, Japan (Hokkaido, Honshu, Shikoku, and Kyushu), and Taiwan. On this plant, *A. caricis* is recorded only from Japan (as *A. caricis* s. lat., Kakishima 1982).

The remaining hosts, *C. deflexa*, *C. inops* subsp. *heliophila*, *C. peckii*, *C. pensylvanica*, *C. rossii*, and *C. umbellata* are North American species. They are reported as infected from Subarctic America to USA. *Carex deflexa* is known as smutted from Greenland.

The records of *Anthracoidea caryophylleae* on *Carex vanheurckii* (from Kamchatka and North Kuriles – Govorova 1990; Azbukina et al. 1995) should be assigned to *A. caricis* (for this fungus-host combination, see additional comments given to *A. caryophylleae*).

Lit.: Kukkonen (1963), Kakishima (1982), Katumoto (2010), Vánky (2011a).

Anthracoidea globularis Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 56, 1963. — Holotype on *Carex globularis*, Finland, Kuusamo, Juuma, Hautaniitynvaoma, 6 Aug 1948, L.E. Kari (TUR); isotypes in Fungi exsic. fenn., no. 124. **Figs 13–16**

Sori in ovaries, scattered in the inflorescence, as subglobose to ellipsoidal, black, hard bodies, 1–2 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view suborbicular, broadly elliptical or irregular in outline, sometimes with protuberances, in plane view $16\text{--}25 \times 14\text{--}22$ ($19.9 \pm 1.8 \times 17.3 \pm 1.7$) μm ($n/1 = 100$), in side view 11.5–14 μm thick, dark reddish brown, frequently covered by a gelatinous sheath; wall unevenly thickened, 1.5–3.5 μm thick, thickest at the angles and protuberances, with 1–3 internal swellings, difficult to be observed in cases of dark coloured spores and thick walls, light-refractive areas present, minutely verruculose (warts up to 0.2 μm high) to punctate. In SEM warts partly fused and arranged into short rows. **Spore germination** of *Anthracoidea*-type (Kukkonen 1963), resulting in a two-celled basidium, 100–150 μm long, the apical cell 30–50 μm long and 4–5 μm thick; producing 2–4 basidiospores on each cell; basidiospores ovoid or obovoid, $5.5\text{--}12 \times 2\text{--}6$ μm .

Host — On *Cyperaceae*: *Carex* sect. *Acrocystis*: *Carex globularis* L.

Distribution within the studied area — On *C. globularis*, Japan and Sakhalin.

Specimen examined.

On *Carex globularis* L.:

Russia: Sakhalin Island, 24 Jul 1906, K. Miyabe & T. Miyagi (as *Ustilago* sp., SAPA) (pl. rev.).

Literature record (specimens not seen).

On *Carex globularis*: Japan (Nannfeldt 1979).

Known host — On *Cyperaceae*: *Carex* sect. *Acrocystis*: *Carex globularis*.

General distribution. **Asia:** Japan, Russia (West Siberia, East Siberia, Far East). **Europe:** Finland, Norway, Russia, Sweden.

Comments — Nannfeldt (1979: 20) reported this species for Japan without citing any specimen or literature source. A specimen of *A. globularis* from Japan, seen by Nannfeldt, may exist in a Swedish or another European herbarium. Based on Nannfeldt's record, this species was reported from Japan by Karatygin & Azbukina (1989: 40) and Azbukina et al. (1995: 26).

No evidence for the presence of *A. globularis* or another species of *Anthracoidea* (or *Cintractia* s. lat.) on *Carex globularis* in Japan were found in literature searches, e.g., Ito

(1936), Kakishima (1982), Katumoto (2010). In the dried reference collections that we studied, there was no specimen collected from Japan.

Anthracoidea globularis is reported here for the first time from Sakhalin Island.

Carex globularis is a temperate-Eurasiatic species, distributed mainly in North Europe, West and East Siberia, and the Far East of Russia, as well as in Mongolia, NE China, Korea, and Japan (Hokkaido). *Anthracoidea globularis* is distributed with its host and at least in Sweden, Finland, and the Russian Far East, it seems to be relatively common.

Lit.: Kukkonen (1963), Nannfeldt (1979), Denchev & Minter (2010d), Vánky (2011a).

On sect. *Anomalae*

Anthracoidea dispalatae Denchev, T. Denchev & Kakish., in Denchev et al., Mycotaxon 115: 410, 2011. — Holotype on *Carex dispalata*, Japan, Honshu, Niigata Pref., Gosen-shi (Nakakanbara-gun), 2 Jun 1912, leg. K. Yoshino (TSH, sine num.!). **Figs 17–20**

Sori in ovaries, scattered in the inflorescence, as subglobose or ovoid, black, hard bodies, 1.8–2 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view moderately irregular, sometimes suborbicular or broadly elliptical in outline, in plane view $19\text{--}26 \times 16.5\text{--}23$ ($22.3 \pm 1.5 \times 19.3 \pm 1.5$) μm ($n/1 = 150$), in side view 11.5–14 μm thick, middle to dark reddish brown, wall slightly unevenly thickened, 1.5–2.5(–3.3) μm thick, without internal swellings, sometimes with one, without light-refractive spots; moderately verruculose to verrucose, warts 0.3–0.6 μm high. In SEM warts often forming small groups or short rows; the wall between the warts finely and irregularly punctate. **Spore germination** unknown.

Host — On *Cyperaceae*: *Carex* sect. *Anomalae*: *Carex dispalata* Boott ex A. Gray.

Distribution within the studied area — On *C. dispalata*, Japan (Honshu).

Specimen examined.

On *Carex dispalata* Boott ex A. Gray:

Japan: Honshu, Niigata Pref., Gosen-shi (Nakakanbara-gun), 2 Jun 1912, leg. K. Yoshino (TSH, sine num., holotype) (pl. rev.).

Known host — On *Cyperaceae*: *Carex* sect. *Anomalae*: *Carex dispalata*.

General distribution. Asia: Japan (known only from the type locality).

Comments — *Carex dispalata* is a representative of sect. *Anomalae* (Egorova 1999). In a recently published monograph from China (Dai et al. 2010), *C. dispalata* was included in sect. *Confertiflorae*. In the current study, for most of the *Carex* species, including *C. dispalata*, the taxonomic scheme of Egorova (1999) is applied. In that scheme, section *Anomalae* is treated in a broad sense including some smaller sections, described by Japanese authors, e.g., *Glaucaeformes* Ohwi, *Molliculae* Ohwi, *Confertiflorae* Franch. ex Ohwi, *Dispalatae* Ohwi, *Alliiformes* Akiyama. On representatives of *Carex* sect. *Anomalae*, there is no other species of *Anthracoidea*.

Carex dispalata is with an Eastern Asiatic distribution. It occurs in the Far East of Russia, Sakhalin Island, south Kuril Islands, Japan (Hokkaido, Honshu, Shikoku, and Kyushu), Korea, and NE and Central China.

Lit.: Denchev et al. (2011c), Vánky (2011a).

On sect. *Aulocystis* (*Frigidae*)

Anthracoidea misandrae Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 82, 1963. — Holotype on *Carex misandra*, Canada, Franklin Distr., Baffin I., Frobisher Bay, c. 3 km E of the airport, 10 Aug 1959, D.B.O. Savile et al. (TUR); isotype in DAOM.

Host — On *Cyperaceae*: *Carex* sect. *Aulocystis*: *Carex stenantha* var. *taisetsuensis* Akiyama.

Distribution within the studied area — On *C. stenantha* var. *taisetsuensis*, Russia (Sakhalin).

Literature record (specimens not seen).

On *Carex stenantha* var. *taisetsuensis* Akiyama:

Russia: Sakhalin (Azbukina et al. 1995, as on *Carex ktausipalii* Meinsh.).

Anthracoidea sempervirentis Vánky, Botaniska Notiser 132: 225, 1979. — Holotype on *Carex sempervirens*, Romania, Transylvania, Rodnei Mts, Mt. Koronjis, 31 Jul 1883, G. Linhart (H.U.V. 164); isotypes in Linhart, Fungi hung., no. 204 (as *Ustilago caricis* on *Carex tristis*). **Figs 21–24**

Sori in ovaries, scattered in the inflorescence, as black, hard bodies, 2–2.5 mm long; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view mostly irregular or angular, in plane view $16\text{--}27 \times 12.5\text{--}21.5$ ($20.7 \pm 2.3 \times 16.9 \pm 1.7$) μm ($n/2 = 100$), single spores may reach up to 32 μm in length, in side view 11.5–13.5 μm thick, dark reddish brown; wall unevenly thickened, 1.6–3.4 μm thick, thickest at the angles, internal swellings lacking, light refractive areas present, minutely to moderately verruculose. In SEM from low, 0.2 μm high warts to densely situated, up to 0.4 μm high warts, often confluent, forming short rows or small groups. **Spore germination** of *Anthracoidea*-type (studied on *Carex firma* and illustrated by Boidol & Poelt 1963: 21, Fig. 21).

Host — On *Cyperaceae*: *Carex* sect. *Aulocystis*: *Carex makinoensis* Franch.

Distribution within the studied area — On *C. makinoensis*, Japan (Shikoku).

Specimens examined.

On *Carex makinoensis* Franch.:

Japan: Shikoku, Kochi Pref., Tosayama-mura, 2 May 1935, leg. ? (as *Cintractia caricis*, SAPA, sine num.) (pl. rev.).

Japan: Shikoku, Kochi Pref., Nagaoka-goory, Osugi-mura, Isodani, 18 May 1933, leg. ? (as *Cintractia caricis*, SAPA, sine num.) (pl. rev.); ditto, sine dat., T. Yoshinaga (as *C. caricis*, TNS-F 230 000) (pl. rev.); ditto, 8 May 1933, T. Yoshinaga (as *C. caricis*, TNS-F 230 001) (pl. rev.).

Known hosts — On *Cyperaceae*: *Carex* sect. *Aulocystis*: *Carex austroalpina* Bech. (*C. ferruginea* subsp. *austroalpina* (Bech.) W. Dietr.), *C. brachystachys* Schrank, *C. ferruginea* Scop., *C. fimbriata* Schkuhr, *C. firma* Host, *C. kitaibeliana* Degen ex Bech., *C. makinoensis*, *C. macrolepis* DC., *C. mucronata* All., *C. scabrostris* Kük., *C. sempervirens* Vill. (principal host).

General distribution. **Asia:** China, Japan. **Europe:** Austria, Bosnia & Herzegovina, Bulgaria, Croatia, Czech Republic, France, Germany, Greece, Hungary, Italy, Montenegro, Poland, Republic of Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Switzerland, Ukraine.

Comments — Morphometric variability of spores of *A. sempervirentis* is presented in Table 1.

Table 1. Morphometric variability of spores of *Anthracoidea sempervirentis*

Hosts / specimens	Length	Width	M $\pm$ 1 σ	n
On <i>Carex makinoensis</i>				
Japan: Shikoku, Kochi Pref., Tosayama-mura (SAPA)	16.5–25.5	13.5–21.5	20.5 $\pm$ 2.0 $\times$ 17.5 $\pm$ 1.7	50
Japan: Shikoku, Kochi Pref., Nagaoka-goori, Osugi-mura, Isodani (TNS-F 230 001)	16.0–27.0	12.5–19.5	20.8 $\pm$ 2.5 $\times$ 16.3 $\pm$ 1.7	50

The principal host of *Anthracoidea sempervirentis* is *Carex sempervirens*. It is a high mountain species of *Carex* distributed in Central and South Europe from where it is known to be infected with smut. *Carex austroalpina*, *C. brachystachys*, *C. ferruginea*, *C. firma*, and *C. mucronata* are also distributed in the mountains of Central and South Europe; *C. fimbriata* – in the Alps, *C. kitaibeliana* – from SE Europe to Turkey, *C. macrolepis* – from S Europe to Turkey. All records of *A. sempervirentis* on these hosts are known from Europe (almost exclusively reported from Central, South, and SE Europe). The fungus is common in the Spanish Pyrenees, Central Europe, Romania, and the Balkan Peninsula, and the status of the populations there is stable.

Carex scabrostris is endemic to China distributed in Tibet and Central China (Qinghai, Gansu, Shaanxi, and Sichuan). The known record of *A. sempervirentis* on that host is from Shaanxi (Guo & Zhang 2004; Guo 2011).

Anthracoidea sempervirentis is reported here for the first time from Japan. *Carex makinoensis* is a new host record for *Anthracoidea sempervirentis*. This plant is distributed in Japan (Shikoku and Kyushu) and Taiwan.

Lit.: Denchev & Minter (2011h), Vánky (2011a).

On sect. *Carex* and sect. *Vesicariae*

Anthracoidea subinclusa (Körn.) Bref., Untersuchungen aus dem Gesamtgebiete der Mykologie 12, Brandpilze 3: 146, 1895. — *Ustilago subinclusa* Körn., in Rabenhorst, Hedwigia 13: 159, 1874. — *Cintractia subinclusa* (Körn.) Magnus, Verhandlungen des Botanischen Vereins der Provinz Brandenburg 37[1895]: 79, 1896. — Type on *Carex riparia*, Germany, Dresden, L. Rabenhorst; isotypes in Rabenhorst, Fungi eur., no. 599 (as *Ustilago olivacea*).

Hosts — On *Cyperaceae*: *Carex* sect. *Carex*: *C. miyabei* Franch. (*C. fedia* var. *miyabei* (Franch.) T. Koyama); *Carex* sect. *Vesicariae*: *Carex saxatilis* L.

Distribution within the studied area — On *C. miyabei*, Japan (Hokkaido), *C. saxatilis*, North Kuriles (Paramushir).

Specimen recorded (not seen).

On *Carex miyabei* Franch.:

Japan: Hokkaido, Uryu-gun, Horokanai-cho, Moshiri, Exp. Forests of Hokkaido University, 10 Sep 1982, leg. Y. Harada, no. 13 067 (Harada 1983) (not existing in HHUF – K. Tanaka, in litt.).

Literature records (specimens not seen).

On *Carex saxatilis* L.:

North Kuriles: Paramushir (Govorova 1990; Azbukina et al. 1995).

Known hosts — On *Cyperaceae*: *Carex* sect. *Carex*: *C. atherodes* Spreng., *C. hirta* L., *C. laeviconica* Dewey, *C. lasiocarpa* Ehrh. var. *lasiocarpa*, *C. lasiocarpa* var. *americana* Fernald (*C. lanuginosa* Michx.), *C. miyabei*, *C. raddei* Kük., *C. trichocarpa* Muhl. ex Willd.; *Carex* sect. *Lupulinae*: *Carex lupuliformis* Sartwell ex Dewey; *Carex* sect. *Paludosae*: *Carex acutiformis* Ehrh.; *Carex* sect. *Tumidae*: *Carex heterostachya* Bunge, *C. melanostachya* M. Bieb. ex Willd., *C. riparia* Curt. subsp. *riparia*, *C. riparia* subsp. *chilensis* (Brongn.) Kük.; *Carex* sect. *Pseudocypereae*: *Carex pseudocyperus* L.; *Carex* sect. *Vesicariae*: *Carex exsiccata* L.H. Bailey, *C. oligosperma* Michx., *C. retrorsa* Schwein., *C. rhynchophysa* Fisch. et al., *C. rostrata* Stokes, *C. rotundata* Wahlenb., *C. saxatilis* (incl. *C. miliaris* Michx., *C. physocarpa* C. Presl), *C. tuckermanii* Boott, *C. vesicaria* L.

General distribution. **Asia**: Azerbaijan, China, Georgia, Japan, Kazakhstan, Russia (West Siberia, East Siberia, Far East), Tajikistan, Uzbekistan. **Europe**: Austria, Belarus, Bulgaria, Czech Republic, Denmark, Estonia, Finland, France, Germany, Hungary, Latvia, Lithuania, Norway, Poland, Romania, Russia, Serbia, Slovakia, Spain, Sweden, Switzerland, UK, Ukraine. **North America**: Canada, USA. **South America**: Argentina, Uruguay.

Comments — From Japan, *Anthracoidea subinclusa* has previously been reported on two host plants: *Carex siderosticta* (Ito 1936; Kakishima 1982; Katumoto 2010) and *C. miyabei* (Harada 1983). However the smut on *Carex siderosticta* is a morphologically distinct species, *Anthracoidea siderostictae*. Thus *A. subinclusa* is only known to occur on *Carex miyabei*.

Based on information, acquired from the Curator of HHUF, the specimen of *A. subinclusa*, collected by Harada (no. 13 067), does not exist. In Harada's article, there is

no detailed description of that specimen but it is noted that the spore ornamentation is 'truncate-verrucose' which is illustrated by a SEM photograph (Harada 1983, Fig. 9). Based on his note about the ornamentation, the SEM photograph, and the sectional affiliation of the host, the record of *A. subinclusa* in Japan is credible.

Carex miyabei includes two varieties. As *C. miyabei* var. *maopengensis* S.W. Su is found only in China (Anhui), it follows that the host plant of the smut fungus, recorded by Harada (1983), is *C. miyabei* var. *miyabei*. This variety occurs in Japan (Hokkaido, Honshu and Kyushu) and Korea. *Carex miyabei* is known to be infected by *A. subinclusa* only in Japan.

Lit.: Harada (1983), Govorova (1990), Azbukina et al. (1995), Vánky (2011a).

On sect. *Chlorostachyae*

Anthracoidea capillaris Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 50, 1963. — Holotype on *Carex capillaris*, Finland, Lapponia enontekiensis, Kilpisjärvi, Mt. Saana, 27 Jul 1955, Y. Mäkinen (TUR). **Figs 25–28**

Sori in ovaries, scattered in the inflorescence, as broadly ellipsoidal to ellipsoidal, black, hard bodies, 1.5–2 mm long, when young covered by a thin membrane, later becoming exposed but partly hidden by the glumes; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view usually irregular or moderately angular, sometimes suborbicular in outline, in plane view $15.5\text{--}22 \times 13\text{--}19$ ($18.5 \pm 1.3 \times 16.2 \pm 1.3$) μm ($n/1 = 50$), in side view 9.5–12 μm thick, dark reddish brown; wall unevenly thickened, 1.5–3 μm wide, thickest at the angles, with common, 1–3(–4) internal swellings, light-refractive areas present; surface punctate to minutely verruculose, warts up to 0.2 μm high. In SEM warts often confluent, forming short rows. **Spore germination** of *Anthracoidea* type (Kukkonen 1963), resulting in a two-celled basidium, 120–170 μm long, the apical cell 40–70 μm long and 3.5–4.5 μm thick; producing 2–3 basidiospores on each cell; basidiospores ellipsoidal, ovoid or obovoid, $(5\text{--}6\text{--}12\text{--}14) \times 2.5\text{--}6$ μm .

Hosts — On *Cyperaceae*: *Carex* sect. *Chlorostachyae*: *Carex capillaris* L., *C. tenuiformis* H. Lév. & Vaniot.

Distribution within the studied area — On *C. capillaris*, Russia (North Kuriles – Shumshu, South Kuriles – Kunashir), *C. tenuiformis*, Japan (Honshu).

Specimen examined.

On *Carex tenuiformis* H. Lév. & Vaniot:

Japan: Honshu, Nagano Pref., Kita-adzumi-gun, Hakuba-mura, Mt. Shirouma-dake, 2933 m, 27 Jul 1950, leg. M. Furuse, no. 22 648 (K, sine num.).

Literature records (specimens not seen).

On *Carex capillaris* L.:

North Kuriles: Shumshu (Govorova 1990; Azbukina et al. 1995).

South Kuriles: Kunashir (Govorova 1990; Azbukina et al. 1995).

Known hosts — On *Cyperaceae*: *Carex* sect. *Chlorostachyae*: *Carex capillaris*, *C. ledebouriana* C.A. Mey. ex Trevir., *C. tenuiformis*.

General distribution. **Asia:** Japan, Russia (Far East). **Europe:** Austria, Finland, Germany, Iceland, Norway, Russia, Slovenia, Sweden, Switzerland, UK, Ukraine. **North America:** Canada.

Comments — *Anthracoidea capillaris* is reported here for the first time from Japan.

A comparative specimen from Norway (Finmark, Varangerhalvöya, Nesseby, Mortensvejn, 70°15' N, 29°02' E, alt. 130 m, 12 Aug 1987, P. Alanko, Vánky, *Ustilag. exsic.*, no. 801) was also studied. Its spores measured $16\text{--}22 \times 12\text{--}17.5$ ($17.9 \pm 1.1 \times 15.3 \pm 1.3$) μm ($n = 100$). The Japanese specimen fits both the data given in the literature for *A. capillaris*, and those of the comparative European specimen.

The type host of *Anthracoidea capillaris*, *Carex capillaris*, is characteristic for the boreal and temperate regions of Europe, Asia, and northern North America. The smut fungus on that host is distributed in North Europe, the Alps, Kurile Islands, and Canada.

Carex ledebouriana subsp. *ledebouriana* is distributed in the Arctic part of European Russia, Siberia, the Far East of Russia, and Central Asia. This sedge is known as a host from the Far East of Russia.

Carex tenuiformis, treated by some authors as a subspecies of *C. ledebouriana* (e.g., by Egorova 1999), is an Eastern-Asiatic species with Manchurian-Sakhalin-Japanese range (occurred in the Far East of Russia, Sakhalin, South Kuriles, Japan – Hokkaido and Honshu, Korea, and NE China). This plant is recorded here for the first time as a host of *Anthracoidea capillaris*.

It is interesting to note that *Carex tenuiformis* has been reported as a host of *Cintractia caricis* from Sakhalin (Ito 1936: 68). This specimen is available in SAPA: S. Saghalin, Kashipo, 31 Jul 1932, Y. Hoshino, H. Abumiya & G. Takee (sub *Cintractia caricis* on *Carex koreana* Kom.) (SAPA, sine num.). Its host plant was revised in 1934 by J. Ohwi, and identified as *Carex tenuiformis*. For the purposes of this study, the correctness of this determination was confirmed by one of us (M.M.). This specimen has remained unnoticed by Russian mycologists (comp. Govorova 1990; Azbukina et al. 1995). Unfortunately, its spores do not match those of *Anthracoidea capillaris* from Europe and we cannot recognize it under that name.

Lit.: Azbukina & Khavkina (1984), Govorova (1990), Azbukina et al. (1995), Denchev & Minter (2010b), Vánky (2011a).

On sect. *Depauperatae*

Anthracoidea michelii Vánky, Botaniska Notiser 132: 223, 1979. — Holotype on *Carex michelii*, Hungary, near Budapest, Solymár, 3 Jun 1917, A. Degen (H.U.V. 122!).

Figs 29–32

Sori in ovaries, scattered in the inflorescence, as subglobose, ovoid or broadly ellipsoidal, black, hard bodies, 2–3 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, variable in shape, in plane view irregular or angular, sometimes with protuberances, $16.5\text{--}24 \times 14.5\text{--}$

19.5 ($19.8 \pm 1.6 \times 16.8 \pm 1.2$) μm ($n/1 = 50$) μm , in side view 10.5–13.5 μm thick, middle to dark reddish brown; wall unevenly thickened, thickest at the angles and protuberances, 1.3–3 μm thick, light-refractive areas common, often abundant, internal swellings absent, sometimes one or two; moderately verruculose, warts up to 0.5 μm high, affecting the spore profile. In SEM warts partly fused, forming small groups and short rows. **Spore germination** unknown.

Host — On *Cyperaceae*: *Carex* sect. *Depauperatae* Meinsh. (sect. *Rhomboidales* Kük., p.p.): *Carex longirostrata* C.A. Mey.

Distribution within the studied area — On *C. longirostrata*, Japan (Honshu).

Specimen examined.

On *Carex longirostrata* C.A. Mey:

Japan: Honshu, Niigata Pref., Gosen-shi (Nakakanbara-gun), 2 Jun 1912, K. Yoshino (as *Anthracoidea caricis* on *Carex* sp., TSH sine num.) (pl. rev.).

Known hosts — On *Cyperaceae*: *Carex* sect. *Depauperatae*: *Carex brevicollis* DC., *C. longirostrata*, *C. michelii* Host.

General distribution. **Asia:** Iran, Japan, Russia (Far East). **Europe:** Austria, Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovakia, Ukraine.

Comments — Two species of *Anthracoidea* on sedges of sect. *Depauperatae* (sect. *Rhomboidales* Kük., p.p.), *A. michelii* and *A. pilosae*, are known. Both of them are described from Europe. The treatment of East Asian specimens of *Anthracoidea* on sedges of sect. *Depauperatae*, and on the closely related sect. *Rhomboidales* s. str., required special attention and revision of the type specimens of *A. michelii* and *A. pilosae*.

Examination of the **holotype** of *A. michelii* (H.U.V. 122) yielded the following description:

Sori in ovaries, scattered in the inflorescence, as broadly ellipsoidal to ellipsoidal, black, hard bodies, 2.5–3.5 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, variable in shape, in plane view irregular or angular, 16–24 $\times$ 14–20 ($20.2 \pm 1.7 \times 17.0 \pm 1.4$) μm ($n = 150$), single spores up to 26 μm long, in side view 11–13 μm thick, middle to dark reddish brown; wall unevenly thickened, thickest at the angles, 1.2–3.5 μm thick, light-refractive areas common, often abundant, 1–2 internal swellings sometimes present; moderately verruculose, warts up to 0.5 μm high, affecting the spore profile. In SEM warts partly fused, forming small groups and short rows. **Spore germination** unknown. **Figs 33–36**

For illustrations of spores from the type, see also Denchev & Minter (2011e: Figs B–D).

Vánky (1979: 225) remarked that a specimen from Hungary (Mt. Hárshegy, pr. Budapest, Jun 1908, G. Szépligeti, BP, H.U.V.) contained both, sori typical of *A. michelii*, as well as sori of another undetermined species of *Anthracoidea*, which was characterised by elongated, finely verruculose, and light-colored spores. Vánky (1979) considered those sori represented either a new species or accidental infection by another species of *Anthracoidea*.

For clarification of the morphological variability of spores of *A. michelii*, we studied two additional specimens on *Carex michelii* from Central Europe.

- (i) **Hungary**, montes Bükk, in monte Nagy-Eged, pr. oppid. Eger, 47°55'15" N, 20°25' E, alt. ca 400 m, 14 Jun 1981, leg. S. Tóth, det. S. Tóth & K. Vánky, Vánky, *Ustilag. exsic.*, no. 332.
- (ii) **Slovakia**, mt. Povážský Inovec pr. oppid. Hlohovec, 48°27' N, 17°50' E, alt. ca 240 m, 29 May 1986, leg. K. Sutorý, det. K. Vánky, Vánky, *Ustilag. exsic.*, no. 554.

These two specimens posses unusually elongated and irregular spores, with length exceeding 26 μm . This kind of spores is not typical of *A. michelii*. The spores of the Hungarian specimen were very variable in shape. Usually, they were irregular and angular but spores that were unusually elongated and irregular, with length exceeding 26 μm (up to 34 μm) were frequently observed. The Slovak specimen also possessed unusually elongated and irregular spores, up to 34 μm long.

Moreover, a specimen of *A. michelii* on *Carex brevicollis* (Bulgaria, prope pagum Dolni Lom, distr. Vidin, leg. V. Čalákov, SOMF 15 195) was examined. The features of this specimen match the description of the holotype, including spore sizes and ornamentation. Unusually elongated spores, like those seen in the Hungarian and Slovak specimens on *Carex michelii*, were not observed. Spores with more than two light refractive areas were also absent.

The spore sizes of the Japanese specimen of *A. michelii* and those of the type and the comparative specimen on *Carex brevicollis* are presented on Table 2.

Table 2. Morphometric variability of spores of *Anthracoidea michelii*

Hosts / specimens	Length	Width	$M \pm 1\sigma$	n
On <i>Carex longirostrata</i>				
Japan: Honshu, Niigata Pref., Gosen-shi (TSH)	16.5–24.0	14.5–19.5	$19.8 \pm 1.6 \times$ 16.8 ± 1.2	50
On <i>Carex michelii</i>				
Hungary: near Budapest, Solymar (H.U.V. 122, holotype)	16.0–24.0	14.0–20.0	$20.2 \pm 1.7 \times$ 17.0 ± 1.4	150
On <i>Carex brevicollis</i>				
Bulgaria: prope pag. Dolni Lom, distr. Vidin (SOMF 15 195)	16.0–24.5	14.0–20.0	$20.7 \pm 1.7 \times$ 17.2 ± 1.6	50

The principal host of *Anthracoidea michelii* is *Carex michelii*, a species distributed in Central, South, and East Europe, the Caucasus, NE Turkey, and NW Iran. The smut fungus on that host is known from a limited number of locations in Central Europe, Ukraine, and Iran.

The second host is *Carex brevicollis*, distributed in Central, South, and East Europe, the Caucasus, and NE Turkey. On that host, a single locality of *A. michelii* is recorded from Bulgaria (Denchev 2001).

The third host, *Carex longirostrata* has an Eastern Asiatic distribution. It occurs in the Far East of Russia, N Kuriles, Sakhalin, Japan – Hokkaido and Honshu, Korea, and NE China. *Carex longirostrata* parasitised by *A. michelii*, has been previously known only from Kamchatka (Govorova 1987, 1990; Azbukina et al. 1995).

Anthracoidea michelii seems to be rare in all countries from which it has been recorded.

In the present work, *A. michelii* is reported for the first time from Japan. The examined specimen has been previously misidentified by Vánky & Harada (1990: 450), and published as *A. pilosae* on *Carex pilosa*.

Lit.: Govorova (1987, 1990), Vánky & Harada (1990), Azbukina et al. (1995), Denchev & Minter (2011e), Vánky (2011a).

Based on the abovementioned observations concerning morphological differences in two Central European specimens of *Anthracoidea* on *Carex michelii*, a new species is proposed here.

Anthracoidea pseudomichelii T. Denchev & Denchev, **sp. nov.**

Figs 37–44

IF 550179

Differs from *A. michelii* by having elongated up to 34 μm , irregular spores; and from *A. pilosae* by having irregularly angular spores, and in the presence of common light refractive areas.

Sori in ovaries, scattered in the inflorescence, as ovoid or broadly ellipsoidal, black, hard bodies, 2–3 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, very variable in shape, in plane view mainly irregular and angular, sometimes with protuberances, elongated up to 34 μm , irregular spores present, $16\text{--}29\text{--}(34) \times 13.5\text{--}21$ ($23.0 \pm 3.2 \times 17.4 \pm 1.8$) μm ($n = 200$) μm , in side view 10–13 μm thick, dark or middle reddish brown; wall unevenly thickened, thickest at the angles and protuberances, 1.3–3(–4) μm thick, light-refractive areas common (a great number of the spores with easily seen light refractive areas, often spores with more than two light refractive areas present); internal swellings absent, sometimes one; moderately verruculose, warts up to 0.5 μm , slightly affecting the spore profile. In SEM warts partly fused, forming groups and short rows. **Spore germination** unknown.

Type on *Carex michelii* Host: Hungary, montes Bükk, in monte Nagy-Eged, pr. oppid. Eger, 47°55'15" N, 20°25' E, alt. ca 400 m, 14 Jun 1981, leg. S. Tóth (**holotype**, SOMF 17 797!; isotypes in Vánky, *Ustilag.* exsic., no. 332). Paratype: on *Carex michelii*, Slovakia, mt. Povážský Inovec pr. oppid. Hlohovec, 48°27' N, 17°50' E, alt. ca 240 m, 29 May 1986, leg. K. Sutory (SOMF 20 406!; isoparatypes in Vánky, *Ustilag.* exsic., no. 554, as *A. michelii*).

Etymology: the name is connected with the epithet of a closely related species, *A. michelii*.

Distribution. Europe: Hungary, Slovakia.

Comments — *Anthracoidea pseudomichelii* differs from *A. michelii* by having longer spores, including unusually elongated and irregular spores, up to 34 µm long. *Anthracoidea pseudomichelii* possesses comparatively more elongated spores, i.e. with a ratio of length mean : width mean = 1.32, while the same ratio of *A. michelii* ranges 1.18–1.21. *Anthracoidea pseudomichelii* differs from *A. pilosae* by having irregularly angular spores, and in the presence of a wall with common and conspicuous light refractive areas.

Anthracoidea pilosae Vánky, Botaniska Notiser 132: 225, 1979. — Holotype on *Carex pilosa*, Hungary, Nógrád Co., Mt. Börzsöny, near Diósjenő, 12 Jun 1955, L. Baksay (H.U.V. 134!); isotype in BP. **Figs 45–48**

Sori in ovaries, scattered in the inflorescence, as subglobose or ovoid, black, hard bodies, 2–3.5 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view suborbicular, broadly elliptic or slightly irregular in outline, in plane view $20.5\text{--}28 \times 16\text{--}24$ ($23.6 \pm 1.2 \times 20.3 \pm 1.6$) µm ($n/1 = 50$) µm, single spores may reach up to 30 µm in length, in side view 12–14.5 µm thick, dark reddish brown; wall slightly unevenly thickened, 1.3–3.5 µm thick, usually internal swellings and light-refractive spots absent; minutely verruculose, warts usually up to 0.3 µm high, densely situated. In SEM warts partly fused, forming small groups and short rows. **Spore germination** unknown.

Host — On *Cyperaceae*: *Carex* sect. *Depauperatae* Meinsh. (sect. *Rhomboidales* Kük., p.p.): *Carex pilosa* Scop.

Distribution within the studied area — On *C. pilosa*, Japan (Hokkaido).

Specimen examined.

On *Carex pilosa* Scop.:

Japan: Hokkaido, Sapporo-shi, Garugawa, 9 Jul 1891, K. Miyabe (as *Ustilago caricis* on *Carex* sp., SAPA, sine num.) (pl. rev.).

Known host — On *Cyperaceae*: *Carex* sect. *Depauperatae*: *Carex pilosa*.

General distribution. **Asia:** Japan, Russia (Far East). **Europe:** Austria, Czech Republic, Germany, Hungary, Lithuania, Romania, Russia, Slovakia, Slovenia, Switzerland, Ukraine.

Comments — The revision of the **holotype** of *A. pilosae* (H.U.V. 134) yielded the following description:

Spores flattened, in plane view irregular or suborbicular to broadly elliptic in outline, in plane view $20\text{--}28 \times 14.5\text{--}23$ ($22.9 \pm 1.5 \times 19.0 \pm 1.9$) µm ($n = 50$) µm, single spores may reach up to 30 µm in length, in side view 12.5–14 µm thick, dark reddish brown; wall unevenly thickened, 1.5–4 µm thick, internal swellings and light-refractive spots rarely present; minutely verruculose, warts usually up to 0.3 µm high, densely situated. In SEM warts partly fused, forming small groups and short rows. **Figs 49–52**

For illustrations of spores from the type, see also Denchev & Minter (2011g; Figs B–D).

An additional comparative specimen on *Carex pilosa* was examined: **Romania**, Moldova, Suceava, pr. pag. Solca, 47°40' N, 25°50' E, alt. ca 500 m, 4 Jul 1980, G. Negrean, in Vánky, *Ustilag.* exsic., no. 387. Its spore measurements are presented in Table 3.

The features of the Japanese specimens match those of the holotype and the comparative Romanian specimen.

Table 3. Morphometric variability of spores of *Anthracoidea pilosae*

Hosts / specimens	Length	Width	M ± 1σ	n
On <i>Carex pilosa</i>				
Japan: Hokkaido, Sapporo-shi, Garugawa (SAPA)	20.5–28.0	16.0–24.0	23.6 ± 1.2 × 20.3 ± 1.6	50
Hungary: Nógrád Co., Borzsony Mt., near Diósjenő (holotype, H.U.V. 134)	20.0–28.0	14.5–23.0	22.9 ± 1.5 × 19.0 ± 1.9	50
Romania: Moldova, Suceava, pr. pag. Solca (Vánky, <i>Ustilag.</i> exsic., no. 387)	19.0–28.0	14.5–22.5	22.6 ± 1.7 × 19.3 ± 1.9	100

A key for distinguishing the *Anthracoidea* species on sedges of section *Rhomboidales* s. lat. was given in Vánky (1994, 2011a). The spores of *A. pilosae* were described as ‘finely verruculose’ unlike *A. michelii*, which has spores that are ‘distinctly verruculose’. In the descriptions of these species, the warts were given as 0.1–0.5 µm high for *A. pilosae*, and 0.15–0.5 µm high for *A. michelii* (Vánky 1994, 2011a). Our revision of the holotypes of these species confirmed that the spores of *A. pilosae* had finer ornamentation (warts up to 0.3 µm high) than the ones of *A. michelii* (warts up to 0.5 µm high), which affected the spore profile. Unfortunately, the height of the warts of *A. pilosae* varied considerably between specimens. In some specimens, including one from Hungary (Vánky, *Ustilag.* exsic., no. 661), the warts were a little bit higher than those of the type. The studied Japanese specimen had a little higher warts than those of the type, and similar to those in Vánky, *Ustilag.* exsic., no. 661.

In this key, the second character for differentiation of *A. pilosae* from *A. michelii* is the presence of light refractive areas. We confirm the applicability of this character. The spore wall of *A. pilosae* rarely has light-refractive areas, while the wall of *A. michelii* has common light-refractive areas, often abundant.

The spore length is the third diagnostic character used by Vánky (1994, 2011a) where the range of the spore length of *A. pilosae* is given as 20–28 µm while that of *A. michelii* is given as 14–24 µm. The maximum spore length of *A. pilosae* is really a little higher than that of *A. michelii*. The spore sizes of the Japanese specimen of *A. pilosae* match those of the holotype.

Additionally, *A. michelii* has spores which are more irregular and angular in outline than those of *A. pilosae* but using this feature as diagnostic for the purposes of a key is unreliable.

Anthracoidea pilosae seems to be rare in all countries from which it has been recorded.

In this treatment, *Carex pilosa* is accepted in its broad sense, i.e. as a temperate-Eurasian species. According to Ohwi (1965), Govaerts et al. (2007), Dai et al. (2010), and Hoshino et al. (2011), *C. pilosa* has a disjunct distribution in Europe (Central, South, and East Europe and the Baltic States) and in East Asia (the Far East of Russia, Sakhalin, Japan – Hokkaido and Honshu, Korea, and NE China). If it is the case, *Anthracoidea pilosae* follows the areal of its host. There are several records of this fungus from eleven countries from Central and East Europe, and the Russian Far East. However, many authors accept *Carex pilosa* as endemic to Europe (e.g., Kreczetowicz 1935; Popov 1970; Chater 1980; Kozhevnikov 1988; Egorova 1999). *Anthracoidea pilosae* needs to be re-collected in Hokkaido to clarify the taxonomic affiliations of its host plant. In the checklists of the vascular plants of Sakhalin (Barkalov & Taran 2004) and Hokkaido (Ito & Hinoma 1985–1994), *Carex campylochorhina* V.I. Krecz. (instead of *C. pilosa*) is given. Popov (1970) and Egorova (1999) treated *Carex pilosa* and *C. campylochorhina* as a vicarious species pair, restricted to Europe and to the Far East of Russia, Sakhalin, South Kuriles, Hokkaido, Honshu, Korea, and NE China, respectively.

There is an additional problem connected with some observations that show that *Carex pilosa* (*C. sect. Depauperatae*) is closely related to sedges from sect. *Paniceae*. Hendrichs et al. (2004: 102) noted that in their phylograms *Carex pilosa* always clustered within section *Paniceae* (with the following analyzed species: *C. panicea*, *C. vaginata*, and *C. falcata*). It is worth mentioning that *Anthracoidea pilosae* (on *Carex pilosa*) and *A. paniceae* (on sedges in section *Paniceae*) are morphologically indistinguishable. The species of *Anthracoidea* known on sedges from sections *Depauperatae*, *Paniceae*, and *Mitratae* need a comprehensive critical revision.

Lit.: Azbukina & Khavkina (1984), Govorova (1987, 1990), Vánky & Harada (1990), Azbukina et al. (1995), Katumoto (2010), Denchev & Minter (2011g), Vánky (2011).

Anthracoidea spp.

Among the studied East Asian specimens of *Anthracoidea* on *Carex longirostrata*, there are two specimens that at this stage cannot be referred to any known species.

- (i) On *Carex longirostrata*: **Russia**, S. Sakhalin, Minami-kotan, 19 Jul 1931, leg. Kimoto, Murayama & Takee (originally, as *Cintractia caricis* on *Carex sabynensis* Franch., later revised by Ohwi as *C. longirostrata*; SAPA, sine num.) (pl. rev.). Description: spores irregular, $17.5\text{--}24.5 \times 14\text{--}21$ ($20.9 \pm 1.9 \times 17.4 \pm 1.7$) μm ($n = 50$), in side view $11.5\text{--}14$ μm thick; wall unevenly thickened ($1.5\text{--}3.5$ μm), light-refractive areas common (sometimes conspicuous), internal swellings absent, sometimes one. It differs from the type of *A. michelii* by having spores with lower ornamentation, and from *A. pilosae*, by having smaller spores and spore walls with common light-refractive areas.
- (ii) On *Carex longirostrata*: **South Korea**, sine loc., April 1990, T.B. Lee (SNUA 76 391). Description: spores irregular and angular, $18.5\text{--}26 \times 14.5\text{--}21.5$ ($21.7 \pm 1.8 \times 17.7 \pm 1.3$) μm ($n = 50$), wall unevenly thickened ($1.0\text{--}4.2$ μm), light-

refractive areas common (sometimes conspicuous), internal swellings common, 1–3. It differs from the type of *A. michelii* by having spores with common internal swellings, and from *A. pilosae*, by having spores with common internal swellings and light-refractive areas.

On sect. *Digitatae*

Anthracoidea humilis Vánky, Mycotaxon 18: 321, 1983. — Holotype on *Carex humilis*, Romania, Transylvania, Odorhei, Mt. Kuvar, alt. 500 m, 12 May 1962, K. Vánky (H.U.V. 100); isotypes in Vánky, *Ustilag. exsic.*, no. 22 (as *Cintractia caricis*) (SOMF 6083!).

Figs 53–56

Sori in ovaries, scattered in the inflorescence, as subglobose or broadly ellipsoidal (to ellipsoidal), black, hard bodies, 1.5–2.5 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view irregular or subpolygonal, rarely with protuberances, in plane view $17\text{--}26.5 \times 15\text{--}23$ ($21.5 \pm 2.0 \times 18.5 \pm 1.6$) μm ($n/3 = 150$), in side view 11–14 μm thick, dark reddish brown; wall unevenly thickened, thickest at the angles, 1.5–4 μm thick, sometimes with 1–3, internal swellings, sometimes with light-refractive areas; minutely to moderately verruculose (warts 0.2–0.4 μm high), sometimes with warts up to 0.5 μm high (affecting the spore profile); in SEM the warts partly confluent. **Spore germination** unknown.

Host — On *Cyperaceae*: *Carex* sect. *Digitatae*: *Carex lanceolata* Boott.

Distribution within the studied area — On *C. lanceolata*, Japan (Honshu).

Specimens examined.

On *Carex lanceolata* Boott:

Japan: Honshu, Aomori Pref., Nishitsugaru, Iwasaki, Kurosaki, Mt. Shirakami, 28 Jun 1981, leg. Y. Harada (as *A. caricis*) (HHUF 11 612).

Japan: Honshu, Tochigi Pref., Iwafune-yama, 14 May 1950, K. Okamoto (TNS-F, sine num.) (pl. rev.).

Japan: Honshu, Ibaraki Pref., Kuji-gun, 1 May 1961, S. Hori (as *Anthracoidea caricis*, TSH, sine num.) (pl. rev.).

Known hosts — On *Cyperaceae*: *Carex* sect. *Digitatae*: *Carex humilis* Leyss. var. *humilis*, *C. lanceolata*, *C. rhizina* subsp. *reventa* (V.I. Krecz.) T.V. Egorova (*C. reventa* V.I. Krecz.).

General distribution. **Asia:** Japan, Russia (Far East). **Europe:** Austria, Bulgaria, Croatia, Czech Republic, France, Germany, Italy, Montenegro, Poland, Romania, Spain, Switzerland.

Comments — In the present study, *Anthracoidea humilis* is reported as a new record for Japan, established on a new host, *Carex lanceolata*. Only *A. caricis* s. lat. from Japan (Ito 1936, as *Cintractia caricis*; Kakishima 1982) and China (Guo 2000), and *A. irregularis* from the Far East of Russia (Govorova 1990; Azbukina et al. 1995) and China (Guo 2007, 2011) have been previously recorded on *Carex lanceolata*. Vánky (2011a) listed *Carex lanceolata* as a host of *A. caricis* and *A. humilis* but excluded this sedge as a host of *A. irregularis*. The specimen

of the Chinese record of *A. irregularis* was not seen by us but based on the description given by Guo, it should be accepted as correctly identified. Thus *Carex lanceolata*, listed by Vánky (2011a) as a host of *A. humilis*, should be referred rather to *A. irregularis*.

Fifteen specimens of *Anthracoidea* on *Carex lanceolata* were found in the studied Japanese and Korean dried reference collections. Some difficulties occurred with the identification of East Asian specimens of *Anthracoidea* on *C. lanceolata*.

The spores of each specimen of *Anthracoidea humilis* on *Carex lanceolata* were characterized with marked variability of height of the warts from low (0.2–0.3 µm high, without palpable effect on the spore profile) to higher (about 0.5 µm high, affecting the spore profile).

For clarification of the morphometrical variability of the spores, we studied an isotype (in Vánky, *Ustilag. exsic.*, no. 22) (Figs 57–60) and four, European specimens of *A. humilis* on the type host, *Carex humilis* (these specimens are listed below).

Examined specimens of *A. humilis* on *Carex humilis*:

Romania: Transsilvania, prope urbem ‘Odorhei’, m. Kuvar, alt. cca 500 m, 12 May 1962, K. Vánky (isotype, Vánky, *Ustilag. exsic.*, no. 22; SOMF 6083).

France: dept. Alpes-de-Haute Provence, 9 km SE. pag. Castellane, ‘Col de Luens’, 43°48’ N, 6°35’ E, alt. c. 1000 m, 8 Jun 1987, leg. F. Oberwinkler et al., det. K. Vánky (Vánky, *Ustilag. exsic.*, no. 601).

Italy: Lombardia, prov. Brescia, pr. Gardone Riviera, ad lacum Garda, 45°37’ N, 10°33’ E, alt. c. 500 m, 30 Apr 1989, leg. U. & K. Vánky, det. K. Vánky (Vánky, *Ustilag. exsic.*, no. 656).

Bulgaria: Regio Znepolae, m. Konjavka pl., in valle fluminis Schegava, 6 May 1986, C.M. Denchev (SOMF 18 504).

Bulgaria: Regio Znepolae, m. Konjavka pl., prope pagum Gurbino, 6 May 1986, C.M. Denchev (SOMF 18 505).

These specimens have spores with irregular or angular shape (but more regular than that of *A. irregularis*). The wall of their spores is unevenly thickened, 1.5–4 µm thick, sometimes with protuberances, sometimes with light refractive areas, 1–3 internal swellings present, and warts no higher than 0.5 µm high (Figs 57–60).

In the description of *A. humilis* (Vánky 1983), it is noted that the height of the warts was ‘c. 0.7 µm high’. The height of the warts in the isotype we studied (as well as that of the other comparative specimens) ranged 0.2–0.5 µm (Figs 59–60).

A second problem we encountered was that in the key to the species of *Anthracoidea* on sedges of sect. *Digitatae*, proposed by Vánky, the internal swellings of *A. humilis* were given as ‘inconspicuous’ (Vánky 2011a: 12), i.e. as difficult for observation. Actually, internal swellings are present and are visible.

A third issue is that in the key (Vánky l.c.) the diagnostic characters (spore length and presence of internal swellings) of one of the species, *A. striata*, do not match the original description of that species (Zhang & Guo 2004: 308). We have not studied the type of this species.

To distinguish the specimens on *Carex lanceolata*, we applied the following approach:

(1) specimens that had distinctly irregular, often elongated spores; with comparatively larger length of the spores (up to 29 µm long, single spores up to 32 µm); that possessed

numerous and conspicuous protuberances, and had well-developed light-refractive areas (often with more than two per spore), were treated as *A. irregularis*;

(2) specimens that had more regular spores than those of *A. irregularis*, without elongated spores; that possessed comparatively smaller spores (up to 25 µm long, rarely up to 26.5 µm), and fewer protuberances and light-refractive areas than those typical of *A. irregularis*, were treated as *A. humilis*.

Among the fifteen specimens of *Anthracoidea* on *Carex lanceolata* from Japan and South Korea, three specimens were recognized as *A. humilis* (listed above as specimens of *A. humilis* from Japan). The features of two of them (in TNS-F and TSH) well matched the respective features of the isotype and comparative European specimens while the specimen from Aomori (HHUF 11 612) had comparatively lower ornamentation. Ornamentation like this is not uncommon for this species. *Anthracoidea humilis* has variable ornamentation but usually, besides spores with low warts, there are some with higher (the warts height of the isotype ranged from 0.2–0.5 µm). The difficulty with the specimen from Aomori Pref. was that the height of its warts (mainly up to 0.3 µm) falls into the lower values of the range measured for the isotype. This observation is noteworthy because if this Japanese specimen had been singly studied and compared with the warts description in the protologue (i.e., ‘c. 0.7 µm high’), it would have been identified as a distinct species, different from *A. humilis*.

The spore morphometric variability of the isotype of *A. humilis* and Japanese specimens on *Carex lanceolata* is presented in Table 4.

Table 4. Morphometric variability of spores of *Anthracoidea humilis*

Hosts / specimens	Length	Width	M ± 1σ	n
On <i>Carex humilis</i>				
Romania: Transsilvania, prope urbem ‘Odorhei’, m. Kuvar (isotype)	17.0–24.5	14.0–21.5	20.1 ± 1.3 × 17.9 ± 1.8	50
On <i>Carex lanceolata</i>				
Japan: Honshu, Aomori Pref., Mt. Shirakami (HHUF 11 612)	17.0–26.5	15.0–21.5	21.8 ± 2.0 × 19.0 ± 1.4	50
Japan: Honshu, Tochigi Pref., Iwafune-yama (TNS-F)	18.0–26.5	15.5–22.0	21.3 ± 2.1 × 18.0 ± 1.6	50
Japan: Honshu, Ibaraki Pref., Kuji-gun (TSH)	17.0–25.5	15.0–23.0	21.5 ± 1.8 × 18.6 ± 1.8	50

The principal host of *Anthracoidea humilis* is *Carex humilis* var. *humilis*. It is a temperate-Eurasian species (Egorova 1999), distributed in Europe, Caucasus, Siberia, Japan, and China. Smut infected plants are only known from Europe. All records of *Anthracoidea humilis* from Europe occur on *Carex humilis*.

Carex lanceolata is a South Eastern Siberian-Eastern Asiatic species with a range part in Mongolia (Egorova 1999). It occurs in East Siberia, Far East of Russia, Japan (Hokkaido, Honshu, Shikoku, and Kyushu), Korea, China, and Mongolia. *Carex lanceolata* represents a new host of *A. humilis*.

The third host, *Carex rhizina* subsp. *reventa* is a Far Eastern sedge, with Kamchatka-Manchurian range (Egorova 1999). It is distributed in East Siberia, Far East of Russia, Korea, and NE China. Plants infected by *Anthracoidea humilis* are known only from the Far East of Russia.

From the Far East of Russia (Magadan Oblast), *A. humilis* is also reported on *Carex pediformis* C.A. Mey. (Govorova 1990; Azbukina et al. 1995). This record needs to be confirmed as it may represent *A. irregularis*.

Lit.: Govorova (1990), Azbukina et al. (1995), Denchev & Minter (2011a), Vánky (2011a).

Among remaining 12 specimens of *Anthracoidea* on *Carex lanceolata*, two specimens were recognized as *A. irregularis*. They are new records for Japan.

One Korean specimen belongs to a new species, described below as *A. lanceolatae*. *Anthracoidea lanceolatae* possesses shorter and more regular spores than those typical of *A. irregularis*, as well as a spore wall that rarely has protuberances. The spore wall of *A. lanceolatae* is also thinner than the walls of *A. irregularis* and *A. humilis*. From *A. humilis* it can also be distinguished by its ornamentation; the warts of most spores of *A. lanceolatae* are larger (up to 0.8 µm high) and are conspicuously affecting the spore profile.

The herbarium packet of another Korean specimen of *Anthracoidea* on *Carex lanceolata* (Seoul, May 1906, Y. Ooe, as *Cintractia caricis*, SAPA, sine num.; pl. rev.) contains no sori but only remnants of spores, and species identification is impossible.

The remaining eight specimens on *Carex lanceolata* (listed below) cannot be unambiguously identified. Based on the spore shape and sizes, and presence and number of protuberances, light-refractive areas, and internal swellings, these specimens are similar to the isotype and comparative European specimens of *Anthracoidea humilis* but differ from them by the higher variability of the height of warts. Some spores of *A. humilis* have unusually high warts, up to 0.7(–0.8) µm, but these specimens cannot be identified as *A. lanceolatae* because the frequency of such spores is considerably lower than that observed for *A. lanceolatae*. The morphometric variability of spores of these specimens is presented in Table 5.

Japanese specimens on *Carex lanceolata* which were not determined as any known species of *Anthracoidea*:

Hokkaido, Sapporo-shi, Shimamatsu, 12 Jun 1932, Y. Hayashi (as *Cintractia caricis*, SAPA, sine num.) (pl. rev.).

Hokkaido, Sapporo-shi, Makomanai, 25 Jun 1933, Y. Homma (as *Cintractia caricis*, SAPA, sine num.) (pl. rev.).

Honshu, Iwate Pref., Minamiiwate-gun, 17 Jun 1897, Y. Takahashi (as *Ustilago caricis*, SAPA, sine num.) (pl. rev.).

Honshu, Iwate Pref., Isunagi near Morioka, 17 Jun 1897, Y. Takahashi (as *Anthracoidea caricis*, TNS-F 229 990) (pl. rev.).

- Honshu, Iwate Pref., Mt. Iwayama, near Morioka, 2 Jun 1932, K. Togashi (as *Cintractia caricis* on *Carex breviculmis* var. *royleana*, SAPA, sine num.) (pl. rev.).
- Honshu, Tokyo, Mt. Takao, Jinba-Asakawa, 23 Apr 1954, N. Hiratsuka & S. Sato (as *Cintractia* sp. on *Carex puberula* Boott, TSH, sine num.) (pl. rev.).
- Honshu, Nagao Pref., Takeshi-mura, 17 Jun 1977, M. Kakishima (as *Anthracoidea* sp., TSH, sine num.) (pl. rev.).
- Honshu, Fukui Pref., Matsuware-mura, 17 May 1922, T. Asano (as *Cintractia caricis*, SAPA, sine num.) (pl. rev.).

Table 5. Morphometric variability of spores of *Anthracoidea* sp. on *C. lanceolata* from Japan

Hosts / specimens	Length	Width	M ± 1σ	n
Hokkaido, Sapporo-shi, Shimamatsu (SAPA)	17.0–24.0	14.5–21.0	20.7 ± 1.6 × 18.1 ± 1.5	50
Hokkaido, Sapporo-shi, Makomanai (SAPA)	16.5–24.5	13.5–21.0	20.3 ± 1.8 × 17.1 ± 1.9	50
Honshu, Iwate Pref., Minamiiwate-gun (SAPA)	16.5–27.5	14.0–22.5	21.9 ± 2.2 × 17.7 ± 2.0	50
Honshu, Iwate Pref., Isunagi near Morioka (TNS-F 229 990)	18.5–25.0	16.0–21.5	21.2 ± 1.5 × 18.5 ± 1.5	50
Honshu, Iwate Pref., Mt. Iwayama, near Morioka (SAPA)	18.5–24.0	15.0–20.5	20.8 ± 1.3 × 17.7 ± 1.2	50
Honshu, Tokyo, Mt Takao, Jinba-Asakawa (TSH)	16.5–24.0	14.0–20.5	21.0 ± 1.8 × 17.6 ± 1.6	50
Honshu, Nagao Pref., Takeshi-mura (TSH)	16.5–25.5	13.0–20.5	20.4 ± 2.0 × 16.6 ± 1.8	50
Honshu, Fukui Pref., Matsuware-mura (SAPA)	16.5–24.5	13.0–20.0	20.4 ± 1.6 × 17.2 ± 1.6	50

Anthracoidea irregularis (Liro) Boidol & Poelt, Berichte der Bayerischen Botanischen Gesellschaft 36: 23, 1963. — *Cintractia irregularis* Liro, Mycotheca Fennica, no. 28, 1934. — *Anthracoidea irregularis* U. Braun & G. Hirsch, Feddes Repertorium 89: 45, 1978 (nom. superfl.). — Type on *Carex digitata*, Finland, Savonia borealis, Kuopio, Puijon-Anttila, 11 Jul 1915, O. Lönnbohm; isotypes in Mycoth. fenn., no. 28.

Figs 61–64

Sori in ovaries, scattered in the inflorescence, as subglobose to broadly ellipsoidal, black, hard bodies, 2–2.2 mm long, when young covered by a thin membrane; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view distinctly irregular, often irregularly angular or elongated, with conspicuous protuberances, in plane view $17\text{--}29 \times 13.5\text{--}22$ ($22.7 \pm 2.3 \times 17.7 \pm 1.7$) μm ($n/2 = 150$), single spores may reach up to 32 μm in length (important to note as a difference from some closely related species where there are no such exceptions), in side view 10.5–13.5 μm thick, medium to dark reddish brown; wall unevenly thickened, 1.5–3 μm thick, thickest at the angles and in the protuberances (up to 5 μm wide), 1–3 internal swellings present, often with well-developed light-refractive areas; minutely to moderately verruculose, sometimes with a slight effect on the spore profile. Viewed with the SEM the warts partly confluent, forming short rows or small groups. **Spore germination** of *Anthracoidea*-type (Kukkonen 1963: 60).

Host — On *Cyperaceae*: *Carex* sect. *Digitatae*: *Carex lanceolata* Boott.

Distribution within the studied area — On *C. lanceolata*, Japan (Honshu).

Specimens examined.

On *Carex lanceolata* Boott:

Japan: Honshu, Miyagi Pref., Sendai, 4 Jun 1905, A. Yasuda (as *Cintractia caricis*, SAPA, sine num.) (pl. rev.).

Japan: Honshu, Ibaraki Pref., Mt. Nantaisan, Jun 1999, C.M. Denchev (pl. rev.).

Known hosts — On *Cyperaceae*: *Carex* sect. *Digitatae*: *Carex digitata* L., *C. lanceolata*, *C. ornithopoda* Willd. subsp. *ornithopoda*, *C. ornithopoda* subsp. *ornithopodioides* (Hausm.) Nyman (*C. ornithopodioides* Hausm.), *C. pallidula* Harmaja (*C. pallens* (Fristedt) Harmaja, *C. digitata* subsp. *pallens* Fristedt), *C. pediformis* C.A. Mey., *C. quadriflora* (Kük.) Ohwi., *C. rhizina* Blytt ex Lindblom subsp. *rhizina* (*C. pediformis* subsp. *rhizodes* (Blytt ex Meinsh.) H. Lindb.), and hybrids between some of these species.

General distribution. **Asia:** China, Japan, Mongolia, Russia (West Siberia, East Siberia, Far East). **Europe:** Austria, Estonia, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, Norway, Poland, Romania, Russia, Serbia, Slovenia, Spain, Sweden, Switzerland.

Comments — The Japanese specimens were compared with a European specimen of *A. irregularis* on *Carex digitata* $\times$ *ornithopoda*: **Austria**, Salzburger Land, Mt. Leoganger Steinberge, 47°29' N, 12°46' E, alt. ca 1700 m, 16 Jul 1987, leg. G. Kost & K. Vánky, det. K. Vánky, in Vánky, *Ustilag.* exsic., no. 657. Its spores are distinctly irregular and angular, sometimes elongated, $18\text{--}27 \times 14\text{--}19.5$ ($22.2 \pm 1.9 \times 17.2 \pm 1.3$) μm ($n = 50$), with common protuberances and light-refractive areas, some spores are with several protuberances and/or light-refractive areas; the walls are unevenly thickened (1.5–5.2 μm thick), with 1–3 internal swellings and warts up to 0.5(–0.6) μm high.

The established spore measurements of the Japanese specimens are presented in Table 6. No difference was found in the variability of spore length and width between the two Japanese specimens, but as a whole, the features of the specimen from Mt. Nantaisan are closer to the original description of *Anthracoidea irregularis*. The specimen from Sendai

possesses slightly more regular spores and has fewer protuberances, although sufficient in number to be recognized as *A. irregularis*.

Table 6. Morphometric variability of spores of *Anthracoidea irregularis*

Hosts / specimens	Length	Width	M ± 1σ	n
On <i>Carex lanceolata</i>				
Japan: Honshu, Miyagi Pref., Sendai (SAPA)	19.0–28.0	13.5–22.0	22.9 ± 2.4 × 17.9 ± 1.7	50
Japan: Honshu, Ibaraki Pref., Mt. Nantaisan	17.0–29.0	14.0–22.0	22.5 ± 2.2 × 17.6 ± 1.7	100

For an explanation of the taxonomic problems in the identification of East Asian specimens of *Anthracoidea* on *Carex lanceolata*, see the notes for *A. humilis*.

Carex digitata is distributed in Europe, West Siberia, Caucasus, Turkey, and Iran, but plants infected by *A. irregularis* are known only from Europe.

The distribution of *Carex lanceolata* is given in the respective rubric to *A. humilis*. Plants of *Carex lanceolata* infected by *A. irregularis*, are known from China (Guo 2007), the Far East of Russia (Govorova 1990; Azbukina et al. 1995), and Japan with the two localities reported here.

Carex ornithopoda subsp. *ornithopoda* is distributed in Europe and Turkey; the records of *A. irregularis* on this host are restricted to Europe. *Carex ornithopoda* subsp. *ornithopodioides* is distributed in Central and South Europe; and plants infected by *A. irregularis* are known only from Austria.

Carex pallidula, distributed in North and Central Europe, is reported as a host in Finland (Harmaja 1991).

Carex pediformis has a distribution in Europe, Caucasus, Siberia, Far East of Russia, Mongolia, and China. Plants of *C. pediformis* s. lat. infected by *A. irregularis* are known from Fennoscandia (Nannfeldt 1979) and Mongolia (Vánky, *Ustilag. exsic.*, nos 456 & 658).

In his notes about the general distribution of *Anthracoidea irregularis*, Nannfeldt (1979: 25) wrote that ‘*Carex pediformis* is known smutted only from Fennoscandia and Japan’. Regarding the Japanese record he neither specified any particular specimen examined by him nor cited the literature source of the initial data. *Carex pediformis* is not listed as a host plant of any species of *Anthracoidea* in Kakishima (1982) or Katumoto (2010). Nannfeldt may have meant a specimen of ‘*Cintractia caricis*’ on *Carex pediformis*, recorded from Japan by Sydow & Sydow (1913), from Iwate Pref., Mt. Iwate (as ‘Prov. Rikuchu, Mt. Ganju’, 30 Jun 1906, leg. Miura, no. 220), and perhaps he presumed that this sedge was infected by *A. irregularis*. Unfortunately, this specimen (or its duplicate) was not found in the visited Japanese dried reference collections. There is no evidence whether this specimen was seen by Nannfeldt or a subsequent author. Moreover, *Carex pediformis* has been observed

recently to be infected by different species of *Anthracoidea*: *A. humilis* in the Far East of Russia (Govorova 1990; Azbukina et al. 1995), *A. irregularis* in the Arctic region of East Siberia (Karatygin 1982; Karatygin et al. 1999), *A. rupestris* Kukkonen in China (Zhang & Guo 2004), and *A. striata* H.C. Zhang & L. Guo in China (Zhang & Guo 2004). It is not certain that the specimen reported by Sydow & Sydow (1913) represents *A. irregularis*. The specimens on *Carex lanceolata* mentioned here represent the first reliable records of *A. irregularis* from Japan.

Carex quadriflora, a sedge from the Far East of Russia, NE China, northern part of the Korean Peninsula, and Hokkaido, is recorded as a host plant of *A. irregularis* from China (Guo 2007).

Carex rhizina subsp. *rhizina* (*C. pediformis* subsp. *rhizodes*) is distributed in North, Central, and East Europe, Caucasus, and West Siberia, and infection by *A. irregularis* is known from Europe (Karatygin & Azbukina 1989; Vánky 1994).

Carex rhizina subsp. *reventa* is distributed in East Siberia, Far East of Russia, Korea, and NE China. As smutted, it is reported only from the Far East of Russia, initially, as a host of *A. irregularis* (Azbukina & Khavkina 1984; Govorova 1987; Vánky 2011), but later corrected as *A. humilis* (Govorova 1990; Azbukina et al. 1995).

In Central Europe, *Anthracoidea irregularis* appears to be relatively common, while for South Europe and the Asian part of its distribution, it is difficult to determine whether the species is rare or rarely collected.

Lit.: Nannfeldt (1979), Azbukina & Khavkina (1984), Govorova (1987, 1990), Azbukina et al. (1995), Denchev & Minter (2011c), Vánky (2011a).

Anthracoidea lanceolatae T. Denchev & Denchev, sp. nov.

Figs 65–72

IF 550180

Sori in ovaries, scattered in the inflorescence, as subglobose or broadly ellipsoidal, black, hard bodies, ca 2.5 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view irregular or polysubangular, more regular than these of *A. irregularis*, rarely with protuberances, in plane view 17.0–25.0 × 14.5–22.5 (20.7 ± 1.7 × 18.0 ± 1.4) µm (n/1 = 100), in side view 10–13.5 µm thick, middle to dark reddish brown; wall unevenly thickened, 1–2.5 µm thick, thickest at the angles and in the protuberances (up to 3.5 µm wide), 1–2 internal swellings present, light-refractive areas absent; verrucose, warts 0.5–0.8 µm high, always affecting the spore profile. Viewed with the SEM the warts partly confluent, forming small groups or short rows. **Spore germination** unknown.

Type on *Carex lanceolata* Boott: South Korea, Mt. Palgong, 30 Apr 1982, leg. Y.N. Lee (holotype, SOMF 28 090!).

Etymology: the name refers to the host species.

Known host — On *Cyperaceae*: *Carex* sect. *Digitatae*: *Carex lanceolata*.

General distribution. Asia: South Korea (known only from the type collection).

Comments — *Anthracoidea lanceolatae* differs from the other, five species of *Anthracoidea* on sedges in section *Digitatae* by the following features:

(1) from *A. irregularis* by more regular and smaller spores, considerably fewer protuberances, the absence of light-refractive areas and the presence of higher warts;

(2) from *A. humilis* by higher warts of all spores (more than 0.5 μm) that always affect the spore profile, and the absence of light-refractive areas;

(3) from *A. shaanxiensis* L. Guo (Guo 2004) on *Carex shaanxiensis* Wang & Tang ex P.C. Li (recorded from China, Shaanxi Prov.), and *A. filamentosae* L. Guo (Guo 2006) on *Carex filamentosa* K.T. Fu (recorded from China, Gansu Prov.), by warts higher than 0.5 μm that always affect the spore profile;

(4) from *A. striata* H.C. Zhang & L. Guo (Zhang & Guo 2004) on *Carex pediformis* C.A. Mey. (observed in China, Xinjiang Prov., with spores 15–30(–37.5) μm long) by having smaller spores.

On sect. *Grallatoriae*

Sydow & Sydow (1909: 173) recorded a specimen of *Cintractia caricis* on *Carex capillacea* Boott (*Carex* sect. *Rarae*) from Japan (Prov. Tosa, Mt. Kunimi, 7 Jun 1908, leg. T. Yoshinaga, no. 5). This specimen is kept at the dried reference collection of the National Museum of Nature and Science, Tsukuba (TNS-F) and was examined by us. Its host plant is misidentified as *C. capillacea*, instead of *C. grallatoria* (*C.* sect. *Grallatoriae*).

Sydow (1924: 288–289) divided *Cintractia caricis* into eleven species, with ten on *Carex* and one on *Elyna*, and selected a type host for each. One of these species, *Cintractia japonica*, was originally described from a host plant identified as *Carex capillacea*. This smut fungus was published with the following description (translated here in English): ‘Spores very variable, usually angularly ellipsoidal, oblong or more or less greatly elongated, 18–26 $\times$ 14–20 μm , the elongated up to 30 μm , occasionally even to 35 μm long, 13–15 μm thick. This form has the smallest sori among the ones examined. On *Carex capillacea* Boott in Japan.’ (Sydow 1924: 288). On p. 284 (op. c.), Sydow specified the following important information about the specimen of *Cintractia* on *Carex capillacea* he examined: ‘The survey covered one specimen from Japan, Prov. Tosa, Mt. Kunimi, leg. Yoshinaga’ (misspelled as ‘Kumini’). This information is combined with a description which is repeated on page 288, where *Cintractia japonica* is described as a new species. This specimen is kept at SAPA. Its host plant was revised in 1934 by J. Ohwi, and identified as *Carex grallatoria* (evidenced by a note on the specimen label) and confirmed by us.

It is noteworthy that both records (Sydow & Sydow 1909; Sydow 1924) were based on hosts that had been misidentified as *Carex capillacea*. Later, both host plants were corrected as *C. grallatoria*. And what is very important, both specimens were collected from the same mountain (Mt. Kunimi), by the same collector (T. Yoshinaga). We consider these specimens as belonging to the same smut fungus.

Since 1924, *Anthracoidea* has not been collected by any subsequent researcher on *Carex grallatoria*. There is nothing about *Cintractia japonica* in Ito (1936), Kakishima (1982), and Katumoto (2010), where *Carex grallatoria* is given as a host of *Cintractia caricis* (in Ito

1936) or *Anthracoidea caricis*. Further there is no information about *Cintractia japonica* in the recently published world monograph of Vánky (2011a).

Vánky (1995) described *A. grallatoriae* on *Carex grallatoria* from Japan. In the introduction to this species, Vánky (1995: 197) wrote: “Revising smut fungi obtained in exchange from Japan (Sapporo, SAPA), a specimen of ‘*Cintractia caricis*’ on *Carex grallatoria* Max., a peculiar sedge being the only member of the sect. *Grallatoriae* Kük. of the subgen. *Carex*, turned out to be an undescribed *Anthracoidea* species”. The type is given as: ‘in matrice *Carex grallatoria* Maxim. (det. J. Ohwi), Japan, Tosa Prov., Mt. Kunimi, 1.VI.1912, T. Yoshinaga. Holotypus in Herbario Ustil. Vánky (HUV 16689!), isotypus in SAPA’ (Vánky 1995: 198). Material for a holotype was separated from the SAPA specimen, and the remaining specimen was proposed as an isotype. In the protologue of *Anthracoidea grallatoriae*, Vánky (1995) did not mention that the host plant had been initially identified as ‘*Carex capillacea*’.

However, the SAPA specimen (as *Cintractia caricis* on *Carex capillacea*), used by Vánky as the type of *Anthracoidea grallatoriae*, is in fact the type of *Cintractia japonica*. The characteristic spore length of this specimen matches precisely the original description of *Cintractia japonica*. On the original label of the SAPA specimen, the name *Cintractia japonica* is not explicitly mentioned but this was not a requirement for a type specimen of a species, at the beginning of the previous century. For an objective interpretation of the type specimen of *Cintractia japonica*, it is significant that Sydow (1924: 284) cited only one specimen of *Cintractia caricis* on *Carex capillacea*. According to Art. 40.3 (Melbourne Code), if a single specimen or gathering is mentioned, even if not explicitly designated as the type, this element is acceptable as indication of the type. We accept Yoshinaga’s specimen of *Cintractia caricis* on *Carex capillacea*, kept at SAPA, as a holotype of *Cintractia japonica*. For this reason, we consider the name *Anthracoidea grallatoriae* as a superfluous name (nom. illegit., Art. 52.1, Melbourne Code), as it includes the type of a name (*Cintractia japonica*), the epithet of which ought to have been adopted. We consequently propose a new combination in *Anthracoidea*.

Anthracoidea japonica (Syd.) Denchev, T. Denchev & Kakish., **comb. nov.**

IF 550182

Basionym: *Cintractia japonica* Syd., Annales Mycologici 22: 288, 1924. — *Anthracoidea grallatoriae* Vánky, Mycotaxon 56: 198, 1995 (nom. illegit., Art. 52.1, Melbourne Code) (syn. nov.). — Holotype on *Carex grallatoria* (originally misidentified as *C. capillacea* Boott; rev. J. Ohwi), Japan, Shikoku, Kochi Pref., Mt. Kunimi, 1 Jun 1912, T. Yoshinaga (SAPA, sine num.!).

Figs 73–80

Sori in ovaries, scattered in the inflorescence, as subglobose, broadly ellipsoidal (to almost ellipsoidal) or ovoid, black, hard bodies, 1.2–1.8 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** slightly flattened, in plane view irregular, subglobose or broadly ellipsoidal, occasionally with protuberances, in plane view 21.5–36.5 × 16.5–28.5 (28.1 ± 3.3 × 21.2

± 2.0) μm ($n/2 = 100$), single spores may reach up to 38 μm in length, in side view 14.5–17 μm thick, dark reddish brown; wall unevenly thickened, thickest at the angles, 1.5–3.5 μm thick, with 1–5 well-developed internal swellings, sometimes with light-refractive areas; moderately verruculose, warts up to 0.4 μm high, sometimes slightly affecting the spore profile. Viewed with the SEM the warts densely spaced, mostly confluent, forming small or large groups, rows or labyrinthiform patterns. **Spore germination** unknown.

Host — On *Cyperaceae*: *Carex* sect. *Grallatoriae*: *Carex grallatoria* Maxim.

Distribution within the studied area — On *C. grallatoria*, Japan (Shikoku).

Specimens examined.

On *Carex grallatoria* Maxim.:

Japan: Shikoku, Kochi Pref., Mt. Kunimi, 1 Jun 1912, leg. T. Yoshinaga (SAPA, sine num., **holotype**) (pl. rev.); ditto, 7 Jun 1908, leg. T. Yoshinaga, no. 5 (as *Cintractia caricis* on *Carex capillacea*) (TNS-F 228 563) (pl. rev.).

Known host — On *Cyperaceae*: *Carex* sect. *Grallatoriae*: *Carex grallatoria*.

General distribution. Asia: Japan (known only from the type locality).

Comments — *Anthracoidea japonica* is characterized by having considerably large spores and very well-developed, 1–5 internal swellings, and by occasional presence of protuberances and light-refractive areas. Morphometric variability of spores of *A. japonica* is presented in Table 7.

Table 7. Morphometric variability of spores of *Anthracoidea japonica*

Hosts / specimens	Length	Width	$M \pm 1\sigma$	n
On <i>Carex grallatoria</i>				
Japan: Shikoku, Kochi Pref., Mt. Kunimi (SAPA, holotype)	21.5–35.0	16.5–28.5	$27.9 \pm 3.3 \times$ 20.5 ± 2.1	50
Japan: ditto (TNS-F 228 563)	22.0–36.5	17.0–26.0	$28.2 \pm 3.4 \times$ 21.9 ± 2.0	50

Anthracoidea japonica is endemic to Japan. The host plant, *Carex grallatoria*, is a single representative of *Carex* section *Grallatoriae*, and is distributed in Japan (Honshu, Shikoku, and Kyushu) and Taiwan.

Lit.: Sydow & Sydow (1909), Sydow (1924), Vánky (1995, 2011a), Katumoto (2010).

During a revision of specimens in the herbarium of the Royal Botanic Gardens, Kew, a specimen of *Anthracoidea* on *Carex grallatoria* was found. It represents a species that differs from *A. japonica*, and is described here as a new.

Anthracoidea caricis-grallatoriae T. Denchev, Denchev & Kakish., **sp. nov.** Figs 81–88
IF 550181

Differs from *Anthracoidea japonica* by having smaller spores and thinner spore walls.

Sori in ovaries, scattered in the inflorescence, as globose, black, hard bodies, 1.2–1.5 mm long; spore mass of the mature sori powdery on the surface. **Spores** flattened in plane view, slightly irregular, suborbicular, broadly ellipsoidal, sometimes ovoid in outline, in plane view $(19.5\text{--}20\text{--}26\text{--}27) \times 16.5\text{--}23$ ($22.9 \pm 1.4 \times 20.2 \pm 1.3$) μm ($n/1 = 200$), in side view $13\text{--}16.5$ μm thick, dark reddish brown, wall unevenly thickened, $0.9\text{--}1.6\text{--}(1.9)$ μm thick, with $1\text{--}4\text{--}(5)$ conspicuous internal swellings, light refractive areas and protuberances absent; moderately verruculose, warts up to 0.5 μm high, slightly affecting the spore profile. Viewed with the SEM the warts partly confluent, forming small groups. **Spore germination** unknown.

Type on *Carex grallatoria* Maxim.: Japan, Yamanashi Pref., Kita-koma-gun, Mukawamura, half stream Ohmi-river, about 1000 m, 24 May 1976, leg. M. Furuse, no. 11 048 (holotype, K(M) 186 846).

Etymology: the name refers to the host species.

Known host — On *Cyperaceae*: *Carex* sect. *Grallatoriae*: *Carex grallatoria* Maxim.

General distribution. Asia: Japan (known only from the type collection).

On sect. *Limosae*

Anthracoidea limosa (Syd.) Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 91, 1963. — *Cintractia limosa* Syd., Annales Mycologici 22: 288, 1924. — Lectotype on *Carex limosa*, Norway, Troms, near Tromsø, Aug 1894, G. Lagerheim (UPS) (design. by Kukkonen 1963: 91); isoelectotypes in Sydow, Ustilag., no. 76 (as *Cintractia caricis*).

Cintractia subglobosa S. Ito, Transactions of the Sapporo Natural History Society 14: 92, 1935. — Holotype on *Carex limosa*, Hokkaido, Nemuro-shi, Shunkuntan, 17 Aug 1924, M. Tatewaki (SAPA, sine num.!) (syn. by Nannfeldt 1979: 28). Figs 89–92

(for additional illustrations of the type, see Vánky & Harada 1990: Figs 3, 4)

Cintractia gigantissima Lehtola, Acta Agralia Fennica 42(1): 129, 1940. — *C. limosa* var. *gigantissima* (Lehtola) Savile, Canadian Journal of Botany 30: 426, 1952. — Type on *Carex rariflora*, no special collection designated (syn. by Kukkonen 1963: 91)

Sori in ovaries, scattered in the inflorescence, as subglobose or ovoid, black, hard bodies, 2.5–3 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view suborbicular, broadly elliptical, elliptical or slightly irregular in outline, more regular than the spores of *A. irregularis*, rarely with protuberances, $18.5\text{--}30 \times 16.5\text{--}24$ ($23.6 \pm 2.1 \times 20.1 \pm 1.8$) μm ($n/1 = 50$), in side view $12\text{--}16$ μm thick, medium to dark reddish brown; wall evenly thickened, $1.3\text{--}2.5$ μm thick, internal swellings absent, light-refractive areas absent;

minutely to moderately verruculose, warts 0.1–0.5 μm high, sometimes slightly affecting the spore profile. Viewed with the SEM the warts partly confluent, forming small groups. **Spore germination** of *Proceres*-type (Kukkonen 1963), resulting in a two-celled basidium, 250–350 μm long; the apical cell 40–70 μm long and 3–6 μm thick; basidiospores cylindrical, rod-shaped, straight or slightly curved, (32–)36–82(–104) $\times$ 3–7 μm .

Hosts — On *Cyperaceae*: *Carex* sect. *Limosae*: *Carex limosa* L. (*C. fuscocuprea* (Kük.) V.I. Krecz.), *C. rariflora* (Wahlenb.) Sm.

Distribution within the studied area — On *C. limosa*, Japan (Hokkaido), North Kuriles (Paramushir), South Kuriles (Kunashir); on *C. rariflora*, North Kuriles (Shumshu, Paramushir).

Specimen examined.

On *Carex limosa* L.:

Japan: Hokkaido, Nemuro-shi, Shunkuntan, 17 Aug 1924, M. Tatewaki (as *Cintractia subglobosa* on *Carex limosa* var. *fuscocuprea*, holotype of *C. subglobosa*; SAPA, sine num.) (pl. rev.).

Literature records (specimens not seen).

On *Carex limosa*:

North Kuriles: Paramushir (Govorova 1990; Azbukina et al. 1995).

South Kuriles: Kunashir (Govorova 1990; Azbukina et al. 1995).

On *Carex rariflora* (Wahlenb.) Sm.:

North Kuriles: Shumshu, Paramushir (Govorova 1990; Azbukina et al. 1995).

Known hosts — On *Cyperaceae*: *Carex* sect. *Limosae*: *Carex limosa*, *C. magellanica* subsp. *irrigua* (Wahlenb.) Hiitonen, *C. pluriflora* Hultén (*C. rariflora* subsp. *pluriflora* (Hultén) T.V. Egorova), *C. rariflora*, and hybrids between some of these species.

General distribution. **Asia:** Japan, Russia (East Siberia, Far East). **Europe:** Austria, Czech Republic, Denmark, Estonia, Finland, Germany, Iceland, Italy, Latvia, Lithuania, Norway, Poland, Russia, Sweden, Switzerland, UK, Ukraine. **North America:** Canada, USA.

Comments — In the protologue of *Cintractia subglobosa* S. Ito (Ito 1935: 92), two specimens, both from Hokkaido, were included. The first specimen, on *Carex limosa* var. *fuscocuprea* Kük., was correctly selected by S. Ito, as a type. This specimen is available in SAPA. The status of the second specimen is explained in the comments to *Anthracoidea buxbaumii*. For reasons unstated, Vánky & Harada (1990: 448) designated the first of these specimens as a lectotype, despite that a type had been selected and explicitly stated in the protologue of *Cintractia subglobosa*, in accordance with the Code. We confirm that the type specimen is kept at Hokkaido University in Sapporo and not lost. In accordance with Art. 9.19.(a) (Melbourne Code), the lectotype selected by Vánky & Harada (1990) is superseded.

Vánky & Harada's (1990) description of *A. limosa*, as a new record from Japan, seems to be based on studies of European specimens but not on the Japanese one. The original description of *Cintractia subglobosa* is brief (Ito 1935: 92). For the first time, a more detailed description of *Anthracoidea limosa*, based on a Japanese specimen, is given here.

From the examination of the type specimen of *Cintractia subglobosa* from Japan, it was established that the maximum spore sizes, especially the spore width, were smaller than those obtained from measurements of European specimens of *Anthracoidea limosa*. Our spore measurements match those obtained by Savile for *Cintractia limosa* var. *limosa*, based on 13 Canadian and five European collections (including an isolectotype specimen). Nannfeldt (1979: 27) and Vánky (1994: 33) noted that this species was very variable in spore sizes and ornamentation. A further comparison of the Japanese specimen with specimens from the Kuriles, Far East of Russia, and North America is warranted.

Carex limosa is a circumboreal species and occurs in Europe, Caucasus, Siberia, Mongolia, NE China, Far East of Russia, Sakhalin, Kuriles, Japan (Hokkaido and Honshu), North Korea, and North America. It is the principal host of *A. limosa*, reported as infected from North and Central Europe, European part of Russia, East Siberia, Far East of Russia, Kuriles, Japan, Canada, and USA.

The second host of *A. limosa* is reported as *Carex magellanica*. Its typical subspecies is known from subantarctic regions from where *A. limosa* is not recorded. Obviously, the records on *Carex magellanica* should be related to its subsp. *irrigua*, distributed in subarctic and temperate regions of the northern hemisphere. On this host, *A. limosa* is known from Fenoscandia, Germany, Alaska, and Canada.

Carex rariflora is distributed in North Europe, Siberia, Far East of Russia, Alaska, and Canada. As infected by *A. limosa*, it is known from Sweden, Finland, the arctic region of the Far East of Russia (Govorova 1987, 1990; Karatygin et al. 1999), northern Kuriles (Shumshu and Paramushir – Govorova 1987, 1990), Alaska, and Canada.

Carex pluriflora has a very interesting geographic range which includes parts of northwestern USA, British Colombia, Alaska, Aleutian Islands, Commander Islands, Paramushir Island, and Sakhalin Island. As infected by *A. limosa*, it is known from Alaska and British Colombia.

Lit.: Ito (1935, 1936), Savile (1952), Nannfeldt (1979), Azbukina & Khavkina (1984), Govorova (1987, 1990), Vánky & Harada (1990), Azbukina et al. (1995), Katumoto (2010), Denchev & Minter (2011d), Vánky (2011a).

On sect. *Mitratae*

Anthracoidea blepharicarpae Denchev, T. Denchev & Kakish., in Denchev et al., Mycotaxon 115: 408, 2011. — Holotype on *Carex blepharicarpa*, Japan, Hokkaido, Sapporo-shi, Mt. Tengu, 19 Jun 1932, leg. Otani et al. (SAPA, sine num.).

Figs 93–100

Sori in ovaries, scattered in the inflorescence, as ellipsoidal or cuneate at base, black, hard bodies, 3–4 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view broadly elliptical, irregular or moderately angular in outline, sometimes elliptical or oval, in plane view 18–30 × 14–25 ($24.4 \pm 2.1 \times 20.7 \pm 1.8$) μm ($n/1 = 150$), as an exception up to 34 μm long, in side view 12.5–15 μm thick, middle to dark reddish brown, wall unevenly thickened, 1–3 μm thick, thickest at the angles, with 1–3(–5) internal

swellings, sometimes with light-refractive spots; minutely (to moderately) verruculose. Spore germination unknown.

Host — On *Cyperaceae*: *Carex* sect. *Mitratae*: *Carex blepharicarpa* Franch.

Distribution within the studied area — On *C. blepharicarpa*, Japan (Hokkaido).

Specimen examined.

On *Carex blepharicarpa* Franch.:

Japan: Hokkaido, Sapporo-shi, Mt. Tengu, 19 Jun 1932, leg. Otani, Yabe, Takee & Murayama (SAPA, sine num., holotype) (pl. rev.).

Known host — On *Cyperaceae*: *Carex* sect. *Mitratae*: *Carex blepharicarpa*.

General distribution. Asia: Japan.

Comments — *Carex blepharicarpa* has an Eastern Asiatic distribution. It occurs in Sakhalin Island, Moneron Island, the Kuriles, Japan (Hokkaido, Honshu, Shikoku, and Kyushu), and Korea (Ullung Island).

As infected by *Anthracoidea* in Japan, *Carex blepharicarpa* has been previously reported only as a host of *A. caricis* s. lat. (Kakishima 1982; Katumoto 2010). As previously explained, numerous *Carex* species that belonged to unrelated sections, were considered to be hosts of *A. caricis* (e.g., Zundel 1953). Currently, the host range of *A. caricis* s. str. is limited to sedges of sections *Acrocystis* (*Montanae*) and *Hallerianae* (Vánky 2011a).

Anthracoidea blepharicarpae differs from the other two members of *Anthracoidea* on *Carex* sect. *Mitratae* (*A. microsora* and *A. caryophylleae*) by having larger spores.

The mean values of the spore length of European specimens of *A. caryophylleae* range from 16.5–20.5 μm (Kukkonen 1963: 18; Nannfeldt 1979: 18; Vánky 1979: 229; Denchev 2001: 90), while those of nine East Asian specimens (from Japan, Korea, Sakhalin Island, and South Kuriles) as measured by us ranged from 18.6–21.3 μm . The mean value of the spore length of these specimens was $20.0 \pm 1.7 \mu\text{m}$ (Table 9). That value is significantly different from the respective mean of $24.4 \pm 2.1 \mu\text{m}$ for *A. blepharicarpae*. The specimen of *A. caryophylleae* from Sakhalin Island had a little higher mean spore length, $21.3 \pm 2.1 \mu\text{m}$ (Table 9), compared with that of the Japanese and Korean specimens, but also differed significantly from the respective mean of *A. blepharicarpae*.

Further, the spores of the European specimens of *A. caryophylleae* were shorter than those of the East Asian specimens (see notes after the description of *A. caryophylleae*).

The mean values of the spore length of sixteen specimens of *A. microsora* as measured by us ranged from 18.8–21.3 (Table 10). The mean value of the spore length of these specimens ($19.6 \pm 1.6 \mu\text{m}$) differed significantly from the respective mean of $24.4 \pm 2.1 \mu\text{m}$ for *A. blepharicarpae*.

Anthracoidea blepharicarpae is known only from the type collection. There is a second *Anthracoidea* specimen on *Carex blepharicarpa*, collected from the same mountain and deposited at the same dried reference collection: Mt. Tengu, 21 Jul 1931, leg. (?) Y. ... (as *Cintractia caricis*, SAPA, sine num.) (pl. rev.). This specimen possesses slightly smaller spores ($19.5\text{--}26 \times 15\text{--}24.5$ ($22.9 \pm 1.6 \times 19.9 \pm 2.1$) μm , $n = 50$) than these of the type of *A. blepharicarpae*, but yet larger than the spores of the European specimens of *A. caryophylleae*

and those of the East Asian specimens (from Japan, Sakhalin Island, the Kuriles, and South Korea) treated here as *A. caryophylleae*. An exact identification of this specimen is difficult; most likely, it is *A. blepharicarpae*.

Meantime, it seems that in Japan, Sakhalin and the South Kuriles, *Carex blepharicarpa* is a host for another *Anthracoidea* species, different from *A. blepharicarpae*, *A. caryophylleae*, and *A. microsora*. That species differs by having higher warts than these of the European specimens of *A. caryophylleae*, but lower than those typical for *A. microsora*. The limited number of taxonomic characters with diagnostic value, do not allow the taxonomic status of this group of specimens to be confidently clarified by the traditional, comparative morphological method. Our hypothesis is that these specimens represent an additional, cryptic species on *Carex blepharicarpa*. Re-collections and examination by molecular methods are needed.

Anthracoidea sp.

Differs from *A. blepharicarpae* by having smaller spores (Table 8), and from the European specimens of *A. caryophylleae* by having higher warts, but not high enough to be treated as *A. microsora*.

Host — On *Cyperaceae*: *Carex* sect. *Mitratae*: *Carex blepharicarpa* Franch.

Distribution within the studied area — On *C. blepharicarpa*, Russia (Sakhalin and South Kuriles), Japan (Rishiri, Hokkaido, Honshu).

Specimens examined.

On *Carex blepharicarpa* Franch.:

Russia: Sakhalin Island, 30 Jun 1906, T. Miyake (as *Ustilago* sp., SAPA) (pl. rev.).

Russia: Kurile Islands, Iturup, Shamanbe, 13 Jul 1906, K. Miura (as *Cintractia caricis*, SAPA) (pl. rev.).

Japan: Rishiri Island, Mt. Rishiri, 15 Jul 1930, M. Terui (as *Cintractia caricis*, SAPA) (pl. rev.).

Japan: Hokkaido, Furano-shi, Rokugoo, 300 m, 1 Jun 1975, M. Furuse, no. 8654 (K, sine num.).

Japan: Hokkaido, Sapporo-shi, Mt. Moiwa, 21 Jun 1925, J. Tanaka (as *Cintractia caricis*, SAPA) (pl. rev.).

Japan: Hokkaido, Sapporo-shi, Makomanai, 15 Jun 1930, M. Terui (as *Cintractia caricis*, SAPA) (pl. rev.).

Japan: Hokkaido, Samani-cho, Mt. Apoi, 9 Jun 1957, Y. Hiratsuka (as *Cintractia caricis* on *C. lanceolata*, TSH S3619) (pl. rev.).

Japan: Honshu, Kanagawa Pref., Hakone, Mt. Komagatake, 1 Jun 1952, Y. Kobayashi (TNS-F, sine num.) (pl. rev.).

Each of these specimens was characterized by the presence of single spores or groups of spores possessing (i) higher warts than those of European, Japanese, and Korean specimens of *A. caryophylleae*, reported in this paper, and (ii) a finely crenulate spore profile. Although the spore wall ornamentation resembles that of *A. microsora*, we prefer to treat them as belonging to a distinct species.

Table 8. Morphometric variability of spores of *Anthracoidea* sp. on *Carex blepharicarpa*

Hosts / specimens	Length	Width	M $\pm$ 1 σ	n
<i>On Carex blepharicarpa</i>				
Russia: Sakhalin Island (SAPA)	18.0–26.5	14.5–20.5	21.3 $\pm$ 2.0 $\times$ 17.7 $\pm$ 1.4	50
Russia: Kurile Islands, Iturup Island, Shamanbe (SAPA)	19.0–26.5	14.5–21.5	21.7 $\pm$ 1.5 $\times$ 18.3 $\pm$ 1.4	50
Japan: Hokkaido, Furano-shi, Rokugoo (K sine num.)	18.5–24.5	15.0–22.5	21.0 $\pm$ 1.4 $\times$ 18.7 $\pm$ 1.5	50
Japan: Hokkaido, Sapporo-shi, Mt. Moiwa (SAPA)	17.5–27.5	14.5–21.5	21.7 $\pm$ 1.8 $\times$ 17.9 $\pm$ 1.9	50
Japan: Hokkaido, Sapporo-shi, Makomanai (SAPA)	18.0–26.0	14.5–20.5	21.6 $\pm$ 1.9 $\times$ 17.7 $\pm$ 1.6	50
Japan: Hokkaido, Samani-cho, Mt. Apoi (TSH S3619)	17.0–24.0	14.5–21.0	20.3 $\pm$ 1.6 $\times$ 17.9 $\pm$ 1.5	50
Japan: Honshu, Kanagawa Pref., Hakone, Mt. Komagatake (TNS-F)	16.5–26.0	14.0–20.0	19.7 $\pm$ 1.8 $\times$ 16.7 $\pm$ 1.5	50

There is a report of *Anthracoidea caryophylleae* on *Carex blepharicarpa* in Moneron Island (an island near Sakhalin) by Govorova (1990) and Azbukina et al. (1995) but we have not revised it. Because we have not established *A. caryophylleae* on *C. blepharicarpa*, this record from Moneron Is. requires re-examination.

Lit.: Denchev et al. (2011c).

Anthracoidea caryophylleae Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 53, 1963. — Holotype on *Carex caryophylleae*, Finland, Ahvenanmaa, Lemland, Hellestorp, 26 Jun 1957, L.E. Kari (TUR). **Figs 101–108**

Sori in ovaries, scattered in the inflorescence, as subglobose to broadly ellipsoidal, sometimes ellipsoidal, black, hard bodies, 1.5–2.5 mm long, when young covered by a thin, whitish membrane, later becoming exposed but partly hidden by the glumes; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view moderately angular or irregular, rarely suborbicular to broadly elliptic in outline, in plane view (14–)16–25(–26) $\times$ 13.5–21.5 (20.0 $\pm$ 1.7 $\times$ 17.1 $\pm$ 1.5) μ m (n/9 = 600), in side view 10.5–13.5 μ m thick, middle to dark reddish brown; wall unevenly thickened, thickest at the angles, 1–3 μ m thick, with 1–3 internal swellings, sometimes with light-refractive areas in the thickest

areas; minutely to moderately verruculose, warts 0.2–0.4 μm high. Viewed with the SEM the warts partly confluent, forming small groups. **Spore germination** of *Anthracoidea*-type (Kukkonen 1963), resulting in a two-celled basidium, 100–150 μm long; producing 2–3 basidiospores on each cell; basidiospores ellipsoidal, ovoid or obovoid, $5.5\text{--}9.5 \times 3\text{--}6 \mu\text{m}$.

Hosts — On *Cyperaceae*: *Carex* sect. *Mitratae*: *Carex foliosissima* F. Schmidt, *C. leucochlora* Bunge, *C. microtricha* Franch. (*C. caryophyllea* var. *microtricha* (Franch.) Kük.), *C. mitrata* var. *aristata* Ohwi, *C. morrowii* Boott, *C. nervata* Franch. & Sav., *C. subebracteata* (Kük.) Ohwi (*C. sabynensis* var. *rostrata* (Maxim.) Ohwi).

Distribution within the studied area — On *C. foliosissima*, Japan (Honshu); on *C. leucochlora*, South Korea (Gangwon Prov.); on *C. microtricha*, Japan (Hokkaido), Russia (Sakhalin), South Kuriles (Iturup); on *C. mitrata* var. *aristata*, Japan (Honshu); on *C. morrowii*, Japan (Honshu); on *C. nervata*, Japan (Honshu); on *C. subebracteata*, Japan (Honshu).

Specimens examined.

On *Carex foliosissima* F. Schmidt:

Japan: Honshu, Tottori Pref., Yazu-gun, Funaoka-machi, 29 May 1976, leg. S. Kaneko (TSH, sine num.) (pl. rev.).

On *Carex leucochlora* Bunge:

South Korea: Gangwon Prov., Yangyang, Mt. Myeongji, 13 May 1989, Y.C. Oh et al. (SWU, sine num.).

On *Carex microtricha* Franch.:

Russia: Sakhalin Island, 19 Jul 1930, H. Ôtani & Y. Imai (as *Cintractia caricis*, SAPA) (pl. rev.).

Russia: Kurile Islands, Iturup, Shamanbe, 19 Jul 1906, K. Miura (as *Cintractia caricis*, SAPA) (pl. rev.).

Japan: Hokkaido, Rusutsu-mura, 26 Jun 1921, Hashimoto (as *Cintractia caricis*, SAPA) (pl. rev.).

Japan: Hokkaido, Otaru-shi, Mt. Kenashi, 9 Jul 1926, leg. S. Nagai (as *Cintractia caricis* on *C. onoei* Franch. & Sav., TNS-F 215 335) (pl. rev.).

On *Carex mitrata* var. *aristata* Ohwi:

Japan: Honshu, Ibaraki Pref., Tsukuba-shi, Tsukuba, 21 May 1985, leg. Osawa (as *Anthracoidea* sp. on *Carex* sp., TSH S4914) (pl. rev.).

On *Carex morrowii* Boott:

Japan: Honshu, Gunma Pref., Tone-gun, Minakami-machi, Hoshi-spa, 29 Aug 1981 (as *Anthracoidea* sp. on *Carex* sp., TSH S4849) (pl. rev.).

On *Carex nervata* Franch. & Sav.:

Japan: Honshu, Iwate Pref., Hanamaki, 17 Jun 1931, S. Murai (as *Cintractia caricis* on *C. breviculmis*, SAPA) (pl. rev.).

Japan: Honshu, Niigata Pref., Kamo-shi, 4 Jun 1914, K. Yoshino (as *Anthracoidea caricis* on *Carex* sp., SAPA) (pl. rev.).

Japan: Honshu, Nagano Pref., Ueda-shi, Sugadaira, 30 Jun 1979, M. Kakishima (as *Carex microtricha*, TSH sine num.) (pl. rev.).

On *Carex subebracteata* (Kük.) Ohwi:

Japan: Honshu, Tochigi Pref., Nasu-machi, 22 May 1940, K. Ide (as *Cintractia caricis* on *C. lanceolata*, TSH S3498) (pl. rev.).

Japan: Honshu, Nagano Pref., Nobeyama, August 1999, C.M. Denchev, no. 9964/i (pl. rev.).

[**Literature records:** on *Carex vanheurckii* Müll. Arg., North Kuriles – Shumshu (Govorova 1990; Azbukina et al. 1995) (specimens not seen; we assume that this sedge is a host of *A. caricis* but not of *A. caryophylleae* – see the comments)].

Known hosts — On *Cyperaceae*: *Carex* sect. *Mitratae*: *Carex breviculmis* R. Br., *C. caryophylleae* Latourr., *C. depressa* subsp. *transsilvanica* (Schur) T.V. Egorova, *C. foliosissima*, *C. huetiana* Boiss., *C. kiangsuensis* Kük., *C. leucochlora*, *C. microtricha*, *C. mitrata* var. *aristata*, *C. morrowii*, *C. nervata*, *C. sabynensis* Less. ex Kunth, *C. subebracteata*, *C. trautvetteriana* Kom., *C. umbrosa* Host; *Carex* sect. *Lamprochlaenae*: *Carex aridula* V. Krecz., *C. asperifructus* Kük., *C. korshinskyi* Kom., *C. liparocarpos* Gaudin subsp. *liparocarpos*, *C. liparocarpos* subsp. *bordzilowskii* (V.I. Krecz.) T.V. Egorova, *C. supina* Willd. ex Wahlenb., *C. turkestanica* Regel.

Other recorded hosts: *Carex* sect. *Acrocystis*: *Carex ericetorum* Pollich, *C. vanheurckii*; *Carex* sect. *Obtusatae*: *Carex obtusata* Lilj.

The status of *Carex blepharicarpa*, as a reported host of *A. caryophylleae*, was briefly discussed in the rubric for comments to *A. blepharicarpae*.

General distribution. **Asia:** Armenia, Azerbaijan, China, Georgia, Iran, Japan, Kazakhstan, South Korea, Mongolia, Russia (West Siberia, East Siberia, Far East), Tajikistan, Turkmenistan, Ukraine, Uzbekistan. **Australia** (New South Wales, Tasmania). **Europe:** Austria, Andorra, Bosnia and Herzegovina, Bulgaria, Czech Republic, Estonia, Finland, France, Germany, Hungary, Italy, Latvia, Lithuania, Norway, Poland, Romania, Russia, Slovakia, Slovenia, Spain, Sweden, Switzerland, UK, Ukraine. **North America:** Canada, USA (Alaska).

Comments — The spore sizes of the specimens are given in Table 9.

Among the *Anthracoidea* specimens from Japan, Sakhalin Island, the Kuriles, and South Korea, discreteness in the values of the spore length and width was not established. It is noteworthy that the mean values of the spore length, ranged from 18.6–21.3 µm, are comparatively higher than those known for the European specimens, which ranged from 16.5–20.5 µm (Kukkonen 1963: 18; Nannfeldt 1979: 18; Vánky 1979: 229; Denchev 2001: 90; Savchenko & Heluta 2012: 291) (see also the discussion to *A. blepharicarpae*).

Comparatively high maximum values of the spore length of *A. caryophylleae* (up to 25(–30) µm) are reported for Chinese specimens on *Carex korshinskyi* Kom. and *C. turkestanica* Regel (both from *Carex* sect. *Lamprochlaenae*) (Guo & Xi 1989; Guo 2000). Unfortunately, no mean values for these specimens are given, and they need re-examination.

It is difficult to make a definite decision whether the East Asian *Anthracoidea* species on hosts from *Carex* sect. *Mitratae* and *Carex* sect. *Lamprochlaenae*, recognized as *Anthracoidea caryophylleae*, is identical with *A. caryophylleae* in Europe. We accept that at least the specimens of *Anthracoidea* on *Carex* sect. *Mitratae* from Japan, South Kuriles, Sakhalin, and South Korea that we examined belong to *A. caryophylleae*.

Table 9. Morphometric variability of spores of *A. caryophylleae*

Hosts / specimens	Length	Width	M ± 1σ	n
On <i>Carex foliosissima</i>				
Japan: Honshu, Tottori Pref., Funaoka-machi (TSH)	16.0–23.0	14.0–20.0	19.6 ± 1.4 × 17.3 ± 1.3	100
On <i>Carex leucochlora</i>				
South Korea: Gangwon Prov., Yangyang, Mt. Myeongji (SWU)	16.5–24.5	14.5–21.5	20.9 ± 1.7 × 17.8 ± 1.7	100
On <i>Carex microtricha</i>				
Russia: Sakhalin Island (SAPA)	17.5–26.0	13.5–21.5	21.3 ± 2.1 × 17.6 ± 1.9	50
Russia: Kurile Islands, Iturup Island, Shamanbe (SAPA)	16.5–25.0	14.0–20.0	20.1 ± 1.9 × 16.7 ± 1.5	50
Japan: Hokkaido, Rusutsu-mura (SAPA)	14.0–22.0	13.5–20.5	18.6 ± 1.6 × 16.7 ± 1.5	50
On <i>Carex nervata</i>				
Japan: Honshu, Niigata Pref., Kamo-shi (SAPA)	17.0–23.5	14.0–19.5	20.1 ± 1.4 × 16.8 ± 1.3	50
Japan: Honshu, Nagano Pref., Ueda-shi, Sugadaira (TSH)	16.0–23.0	13.5–20.5	19.1 ± 1.4 × 16.8 ± 1.4	100
On <i>Carex subebracteata</i>				
Japan: Honshu, Tochigi Pref., Nasu-machi (TSH S3498)	17.0–25.0	14.0–21.0	20.5 ± 2.2 × 17.2 ± 1.6	50
Japan: Honshu, Nagano Pref., Nobeyama	16.5–24.0	14.5–21.0	20.2 ± 1.5 × 17.2 ± 1.6	50

The principal host of *Anthracoidea caryophylleae* is *Carex caryophyllea*, a species distributed in temperate areas of Europe and Asia: Atlantic, Central and South Europe, Caucasus, NE Turkey, Iran, Central Asia, and Siberia. The smut fungus on that host is a common species in Europe (incl. the European part of Russia); it is among the most frequently collected species of smuts in Central and East Europe and the Balkan Peninsula (Denchev & Minter 2010c).

In China, *A. caryophylleae* is found on sedges from sect. *Mitratae* (*C. kiangsuensis*) and section *Lamprochlaenae* (*C. aridula*, *C. asperifructus*, *C. korshinskyi*, and *C. turkestanica*) (Guo & Xi 1989; Guo 1994, 2000).

In East Asia (Far East of Russia, Kuriles, Sakhalin, and Japan) *Anthracoidea caryophylleae* was reported on sedges from sect. *Mitratae* (*Carex leucochlora*, *C. microtricha*, *C. nervata*, *C. sabyensis*, *C. subebracteata*, and *C. trautvetteriana*), sect. *Acrocystis* (*Carex vanheurckii*), and sect. *Lamprochlaenae* (*Carex korshinskyi*) (Govorova 1987, 1990; Karatygin & Azbukina 1989; Vánky & Harada 1990; Azbukina et al. 1995).

Carex leucochlora has an Eastern Asiatic distribution. It occurs in North China, Far East of Russia, Japan, Korea, and North Vietnam. Some authors (e.g., Ohwi 1965; Govaerts et al. 2007; Dai et al. 2010) treat this species as a synonym of *C. breviculmis* var. *breviculmis* but according to Egorova (1999: 252), *C. leucochlora* is a distinct species. *Carex breviculmis* differs from *C. leucochlora* by having utricles with numerous, well distinct veins. *Carex leucochlora* is recorded here for the first time as a host of *Anthracoidea caryophylleae*. Further this is the first reported occurrence of *A. caryophylleae* in the Korean Peninsula.

Carex breviculmis is distributed in SE Asia, New Guinea, Australia, and New Zealand; with infection by *Anthracoidea caryophylleae* known from Australia (Vánky & Shivas 2008).

Another host plant, *Carex hypochlora* Freyn, has been also reported from the Far East of Russia (Govorova 1990). According to Egorova (1999), it is a synonym of *C. leucochlora*, although Dai et al. (2010) recognize it as a distinct species. However, the Govorova's record was not considered by Azbukina et al. (1995) most likely due to awareness of the misidentification of the host. Similarly, *Carex umbrosa*, reported from the Far East of Russia by Govorova (1990), was also excluded in Azbukina et al. (1995).

Carex microtricha has an Eastern Asiatic distribution. It occurs in the Far East of Russia, Commander Islands, Sakhalin, South Kuriles, Japan (Hokkaido and Honshu), and Korea. Some authors (e.g., Govaerts et al. 2007; Koopman 2011) treat this taxon at variety rank, *C. caryophyllea* var. *microtricha* (Franch.) Kük. In the current study, we follow the status suggested by Egorova (1979, 1999) and Kozhevnikov (1988). Smut infected plants of *Carex microtricha* are known from Kamchatka and Sakhalin (Azbukina et al. 1995), and Hokkaido (Vánky & Harada 1990). This fungus-host combination is reported here for the first time from the Kuriles.

Carex nervata has an Eastern Asiatic distribution. It occurs in the Far East of Russia, Japan (Hokkaido, Honshu, Shikoku, and Kyushu), NE China, and Korea, with infection by *A. caryophylleae* known only from the Far East of Russia. We report this fungus-host combination for the first time from Japan. It is noteworthy that according to Egorova (1999), there is only one reliable locality of *C. nervata* in the Far East of Russia, situated in the Ta-Chingouz Bay (the southern branches of the Sihote-Alin Mts). The locality reported by Govorova (1987, 1990) is also situated in the southern Sihote-Alin Mts but much more westward, in the Chandalaz Range. From all of the available specimens of *C. nervata* from the Far East of Russia, Egorova (1999) recognized only one as belonging to this species (that from the Ta-Chingouz Bay). The rest of the specimens were referred by her to *Carex subebracteata*, *C. leucochlora*, *C. umbrosa* subsp. *pseudosabyensis* or *C. microtricha*. Thus the

host plant of the specimen, reported by Govorova (1987, 1990), and cited by Azbukina et al. (1995), needs re-examination.

Two *Anthracoidea* records on *Carex nervata* are reported by Kawai & Ôtani (1931: 230) from the eastern coast of the southern Sakhalin (as *Cintractia caricis* on *Carex caryophyllea* subsp. *nervata*; Shikka, 19 Jul 1930, and Higashi-Taraika, 23 Jul 1930, both collected by H. Ôtani & Y. Imai). According to Ohwi (1965), Egorova (1999), and Barkalov & Taran (2004), *Carex nervata* is not distributed in Sakhalin. These specimens were found by us in SAPA and their host plants and fungal species were revised. The first specimen includes *Anthracoidea caryophylleae* on *Carex microtricha*, while the fungus in the second specimen is *A. paniceae* on *Carex vaginata* var. *vaginata*.

Carex sabynensis is distributed from the European part of Russia to Japan. As a host of *A. caryophylleae*, it is known from Arctic Russia (West Siberia) and the Far East of Russia.

Carex subebracteata is distributed in East Siberia, the Far East of Russia, NE China, Korea, and Japan (Honshu and Kyushu). As a host of *A. caryophylleae*, it has been known from the Far East of Russia. We report this fungus-host combination for the first time from Japan.

Carex trautvetteriana has distribution in East Siberia and the Far East of Russia; as a host of *A. caryophylleae*, it is known from the Far East of Russia.

Carex vanheurckii occurs in East Siberia, the Far East of Russia (incl. Sakhalin and the Kuriles), NE China, Korea, and Japan. As a host of *A. caryophylleae*, it is known from Kamchatka and North Kuriles (Govorova 1990). According to Popov (1970: 88) and Egorova (1999: 683), *C. vanheurckii* is a rather closely related species to *C. pensylvanica* Lam., both distributed in temperate regions but the former from East Asia while the latter from North America. Roalson et al. (2001) showed that section *Acrocystis* is polyphyletic. The established core *Acrocystis* clade includes five North American species (*C. communis*, *C. leucodonta*, *C. pensylvanica*, *C. rossii*, and *C. rugosperma*), two Eurasian species (*C. ericetorum* and *C. pilulifera*), and a species restricted to Far East Asia (*C. oxyandra*). Kukkonen (1963) and Nannfeldt (1979) assigned *C. ericetorum* to the hosts of *A. caryophylleae*. Further, a second species of *Carex* sect. *Acrocystis*, *C. vanheurckii*, was referred as a host of *A. caryophylleae* by Govorova (1990). Based on the affinity, demonstrated by Roalson et al. (2001), there is a need for further research to determine if the *Anthracoidea* species on *C. vanheurckii* and *C. ericetorum* is not *A. caricis*. Hendrichs et al. (2005) confirmed the non-monophyletic nature of section *Acrocystis* (as *C. sect. Montanae*) but in their analyses, the pairs *C. pilulifera* and *C. oxyandra*, and *C. pensylvanica* and *C. ericetorum* were clustered in two different, distantly related groups which indicated more complicated relationships. Tentatively, we consider that the smut fungus on *C. vanheurckii* is *Anthracoidea caricis*.

Carex korshinskyi is distributed in West and East Siberia, the Far East of Russia, Mongolia, China, and Korea; as a host of *A. caryophylleae*, it is known from China and the Far East of Russia.

In the present work, *Carex mitrata* is reported for the first time as a host plant of *A. caryophylleae*, as well as a host of a species of *Anthracoidea*. The spore morphology (shape, sizes, wall thickness, internal swellings, and ornamentation) of the cited specimen (TSH S4914) fits well that of *A. caryophylleae*. *Carex mitrata* is distributed in Japan (Honshu, Shikoku, and Kyushu), S. China, and Taiwan.

In the present treatment, we report for the first time *Carex foliosissima* and *C. morrowii* as host plants of *Anthracoidea caryophylleae*. *Carex foliosissima* is with an Eastern Asiatic distribution. It occurs in Sakhalin, S. Kuriles, and Japan (Hokkaido, Honshu, Shikoku, and Kyushu). *Carex morrowii* is endemic to Japan (Honshu, Shikoku, and Kyushu).

For a long time, the status of *C. foliosissima* in the classification of *Carex* has been uncertain. In Popov (1970), *C. foliosissima* is recognized as a member of *C. sect. Sinocarex* V. Krecz., a related section to *C. sect. Rhomboidales* and *C. sect. Paniceae*. The name *Carex sect. Sinocarex* (nom. inval., published without a Latin diagn.) is treated by Egorova (1999) as a synonym of *C. sect. Rhomboidales*. According to Kozhevnikov (1988) and Egorova (1999), *C. foliosissima* belongs to *C. sect. Rhomboidales*. In Egorova's taxonomic scheme of *Carex sect. Depauperatae* and *C. sect. Rhomboidales*, the following species (of interest as host plants of *Anthracoidea*) are included:

Carex sect. Depauperatae Meinsh. (sect. *Rhomboidales* Kük., p.p.)

Carex brevicollis DC.

C. longirostrata C.A. Mey.

C. michelii Host

C. pilosa Scop.

Carex sect. Rhomboidales Kük.

Carex foliosissima F. Schmidt

C. morrowii Boott

In this taxonomic scheme, *C. sect. Rhomboidales* includes 25 species from East and SE Asia. The application of this scheme to the taxonomy of the genus *Anthracoidea* would have been very convenient if there had not been evidences for close relationships between some species from these sections with species belonging to *C. sect. Mitratae* and *C. sect. Paniceae* (on which there are six *Anthracoidea* species). Egorova (1999: 238) marked some characters by which species from *C. sect. Rhomboidales* demonstrate relationships with species in *C. sect. Mitratae*. Recent molecular studies demonstrated that *Carex foliosissima* and *C. morrowii* are members of sect. *Mitratae*, e.g., Waterway et al. (2009: 151) revealed that *C. fernaldiana* and *C. foliosissima* are closely related species belonging to the section *Mitratae*.

The correct identification of specimens of *Anthracoidea* on *Carex foliosissima* and *C. morrowii* is essential for the development of a modern taxonomic scheme for *Anthracoidea* in East Asia. Based on the difficulties which we encountered with their identification, we suspect that in this region more than one species attacks these sedges.

At the commencement of our study, *Carex foliosissima* was known as a host for a single species, *A. microsora* (Kukkonen 1963: 56; Vánky 2011). We studied four *Anthracoidea* specimens on *Carex foliosissima*, including the specimen, identified by Kukkonen (1963: 56) as *A. microsora*. One of these specimens (Honshu, Tottori Pref., Yazu-gun, Funaoka-machi, TSH, sine num.) was recognized by us as *A. caryophylleae*. The spores of this specimen can be characterized as follows: irregular or angular, 16–23 µm long (see Table 9), single spores up to 25 µm long, middle or dark reddish brown; wall unevenly thickened, thickest at the angles (up to 3 µm); at least half of the spores with 1–3 internal swellings; light-refractive areas absent, rarely one per spore present; wall verruculose, warts like those of *A. caryophylleae*.

The remaining three specimens cannot be explicitly recognized as *A. caryophylleae* or *A. microsora*, because they either (i) possess lower spore ornamentation than *A. microsora*, and more distinct and denser ornaments than those of *A. caryophylleae*; or (ii) have spores with lower ornamentation than typical for *A. microsora*, and more rounded spores than seen in *A. caryophylleae*. These specimens are considered here as *Anthracoidea* sp.

Specimens examined.

On *Carex foliosissima*:

Japan: Honshu, Kyoto-fu, Kibune, north of Kyoto, 21 May 1953, leg. T. Koyama, no. 171 (DAOM 38 521; in Kukkonen 1963, as *A. microsora*). The spores of this specimen possess higher ornamentation than those of *A. caryophylleae*, but not corresponding to that, characteristic of *A. microsora*. Its spores measured $17\text{--}24.5 \times 15.5\text{--}21.5$ ($20.6 \pm 1.3 \times 18.2 \pm 1.2$) μm ($n = 100$).

Japan, 2 Jun 1900 (TSH, sine num.) (pl. rev.). The spores correspond to those of *A. caryophylleae* but the specimen cannot be reliably identified.

Japan, July 1912 (TSH, sine num.) (pl. rev.). The spore ornamentation is similar to that of *A. caryophylleae* but the spores are more rounded than it is characteristic of European specimens of *A. caryophylleae*.

At the commencement of our study, *Carex morrowii* was recorded as a host of a single species, *A. caricis*, s. lat. (Kakishima 1982: 27; Katumoto 2010: 38). This record was referred by Vánky (2011a: 51) to *Anthracoidea michelii* because of the placement of *C. morrowii* in *C.* sect. *Rhomboidales*, s. lat.

As mentioned above, *C. morrowii* belongs to *C.* sect. *Mitratae*. In the Japanese dried reference collections, there are six specimens with *Anthracoidea* on *C. morrowii*. One of them, TSH S4849, matches well the spore morphology of *A. caryophylleae*. However, the remaining five specimens cannot be reliably referred to *A. caryophylleae* or *A. microsora*. The spore morphology of these specimens does not fit that of *A. michelii*, i.e. light-refractive areas rarely present; the spore shape is more regular than that of the type of *A. michelii*, or of *A. pilosae*, which has larger spores. These specimens are considered here as *Anthracoidea* sp.

Specimens examined.

On *Carex morrowii*:

Japan: Honshu, Ibaraki Pref., Gozenyama, 3 May 1979, leg. M. Kakishima (TSH, sine num.) (pl. rev.). Spores $17\text{--}25.5 \times 14\text{--}20$ ($20.9 \pm 2.0 \times 17.4 \pm 1.4$) μm ($n = 50$).

Japan: Honshu, Kanagawa Pref., Hakone, Komagatake, 1 Jun 1952, leg. Y. Kobayashi (as *Anthracoidea* sp. on *Carex* sp., TNS-F, sine num.) (pl. rev.). Spores $16.5\text{--}26.5 \times 14.5\text{--}21$ ($20.0 \pm 2.0 \times 17.5 \pm 1.6$) μm ($n = 50$).

Japan: Honshu, Wakayama Pref., Shichikawa, 5 Apr 1937, M. Takewaki (sub *Cintractia caricis*, SAPA, sine num.) (pl. rev.). Spores $16.5\text{--}24.0 \times 15.5\text{--}21$ ($20.0 \pm 1.7 \times 18.3 \pm 1.3$) μm ($n = 50$).

Japan: Shikoku, Kochi Prov., Tosa, Tosayama-mura, Nakagiri, 12 May 1935, T. Yoshinaga (sub *Cintractia caricis*, SAPA, sine num. & TNS-F 230 003) (pl. rev.). Spores $17.5\text{--}26.5 \times 14.0\text{--}21.5$ ($21.2 \pm 1.7 \times 18.0 \pm 1.3$) μm ($n = 100$).

Japan: Shikoku, Kochi Prov., Tosa, Makinoyama-mura, 21 May 1935, T. Yoshinaga (sub *Cintractia* sp. on *Carex reinii* Franch. & Sav., SAPA, sine num. & TNS-F 230 008) (pl. rev.). Spores $18\text{--}24.5 \times 17\text{--}23$ ($21.5 \pm 1.3 \times 19.7 \pm 1.2$) μm ($n = 50$).

Lit.: Kawai & Ôtani (1931), Kukkonen (1963), Govorova (1987, 1990), Karatygin & Azbukina (1989), Vánky & Harada (1990), Azbukina et al. (1995), Denchev & Minter (2010c), Katumoto (2010), Denchev et al. (2011c), Vánky (2011a).

Anthracoidea microsora (Syd.) Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 55, 1963. — *Cintractia microsora* Syd., Annales Mycologici 22: 289, 1924. — Type on *Carex duvaliana*, Japan, Takao, Musashi, 8 May 1899, S. Kusano (UPS); isotypes in Sydow, Ustilag., no. 223 (as on '*Carex remota*', revised by Kukkonen 1963: 55). Figs 109–116

Sori in ovaries, scattered in the inflorescence, as subglobose to ellipsoidal, black, hard bodies, 1.5–2.5 mm long; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view mainly irregular or angular, sometimes broadly elliptical to elliptical in outline, in plane view $15\text{--}25$ ($\text{--}26.5$) $\times$ $13\text{--}22$ ($19.6 \pm 1.6 \times 16.7 \pm 1.4$) μm ($n/16 = 850$), in side view 10.5–13 μm thick, middle to dark reddish brown; wall unevenly thickened, 1.3–2.5 ($\text{--}3.5$) μm thick, thickest at the angles, internal swellings common, 1–3 ($\text{--}5$), light-refractive areas rare, moderately verruculose to verrucose, warts 0.4–0.6 μm high, affecting the spore profile. Viewed with the SEM the warts partly confluent, forming small groups and short rows. **Spore germination** unknown.

Hosts — On *Cyperaceae*: *Carex* sect. *Mitratae*: *Carex alterniflora* Franch. var. *alterniflora* (*C. sachalinensis* var. *alterniflora* (Franch.) Ohwi), *C. duvaliana* Franch. & Sav., *C. fernaldiana* H. Lév. & Vaniot (*C. sachalinensis* var. *fernaldiana* (H. Lév. & Vaniot) T. Koyama), *C. stenostachys* var. *cuneata* (Ohwi) Ohwi & T. Koyama, *C. stenostachys* s. lat., *C. tenuinervis* Ohwi, and (?) *C. pisiformis* Boott var. *pisiformis*.

Distribution within the studied area — On *Carex alterniflora* var. *alterniflora*, Japan (Honshu, Shikoku); *C. duvaliana*, Japan (Honshu); on *C. fernaldiana*, Japan (Honshu, Shikoku); on *C. stenostachys* var. *cuneata*, Japan (Honshu); on *C. stenostachys* s. lat., Japan (Honshu); on *C. tenuinervis*, Japan (Kyushu); (?) on *C. pisiformis* var. *pisiformis* (Honshu).

Specimens examined.

On *Carex alterniflora* Franch. var. *alterniflora*:

Japan: Honshu, Aomori Pref., Chinnba-yama, 13 May 1951, Y. Kobayashi (as *Anthracoidea* sp. on *Carex* sp., TNS-F, sine num.) (pl. rev.).

Japan: Honshu, Aomori Pref., Mt. Iwaki prope Hirosaki, 40°39' N, 140°18' E, alt. ca 1620 m, 11 Sep 1988, leg. A. Sayama, M. Sasaki & K. Vánky (Vánky, *Ustilag.* exsic., no. 1312).

Japan: Honshu, Niigata Pref., Shigekura-yama, 11 May 1919, leg. ? (as *Ustilago* sp., TNS-F, sine num.) (pl. rev.).

Japan: Honshu, Ibaraki Pref., Ryujin valley, 1978, N. Hirai et al. (TSH) (pl. rev.).

- Japan:** Honshu, Tokyo, Mt. Takao, 8 May 1899, S. Kusano (as *Cintractia caricis* on *Carex remota*, TNS-F 230 007) (pl. rev.).
- Japan:** Honshu, Tottori Pref., Tottori, 16 May 1937, N. Hiratsuka (as *Cintractia caricis* on *Carex blepharicarpa*, TSH) (pl. rev.).
- Japan:** Shikoku, Kochi Pref., Tosayama-mura, Nakagiri, 12 May 1935, leg. ? (as *Cintractia caricis*, SAPA) (pl. rev.).
- Japan:** Shikoku, Kochi Pref., Tosa, Kagami-mura, Hirose, 12 May 1935, T. Yoshinaga (as *Cintractia caricis*, TNS-F 230 002) (pl. rev.).
- Japan:** Shikoku, Kochi Pref., Tosa, 2 May 1935, T. Yoshinaga (as *Cintractia caricis*, TNS-F 230 004) (pl. rev.).
- Japan:** Shikoku, Kochi Pref., Taisenji, 19 Apr 1937, leg. ? (as *Cintractia caricis* on *Carex multiflora* Ohwi, SAPA) (pl. rev.); ditto, 19 Apr 1937, leg. ? (as *Cintractia caricis* on *Carex tristachya* Thunb., SAPA) (pl. rev.).
- On *Carex duvaliana* Franch. & Sav.:
Japan: Honshu, Shizuoka Pref., Uri-toge, 11 May 1953, leg. T. Koyama, no. 143 (DAOM 38 525).
- On *Carex fernaldiana* H. Lévl. & Vaniot:
Japan: Honshu, Tochigi Pref., Nikko, 25 Jun 1905, leg. ? (as *Cintractia* sp. on *Carex* sp., TNS-F 230 009) (pl. rev.).
Japan: Honshu, Nagano Pref., Minami-saku-gun, Minamimaki-mura, Nobeyama, August 1999, C.M. Denchev, no. 9961 (pl. rev.); ditto, August 1999, C.M. Denchev, no. 9962 (pl. rev.); ditto, August 1999, C.M. Denchev, no. 9963 (pl. rev.).
Japan: Honshu, Nagano Pref., Minami-saku-gun, Kawakami-mura, Gosyodaira, 20 Jul 2012, leg. Y. Yamaoka (as *Anthracoidea* sp. on *Carex* sp.) (pl. rev.).
Japan: Shikoku, Kochi Pref., Makinoyama-mura, 21 May 1935, T. Yoshinaga (as *Cintractia caricis*, SAPA) (pl. rev.).
- On *Carex stenostachys* var. *cuneata* (Ohwi) Ohwi & T. Koyama:
Japan: Honshu, Iwate Pref., Minamiiwate-gun, 17 Jun 1897, leg. Y. Takahashi (as *Cintractia caricis*, SAPA, sine num.) (pl. rev.).
- On *Carex stenostachys* s. lat.:
Japan: Honshu, Kyoto-fu, Kibune, north of Kyoto, 21 May 1953, leg. T. Koyama (*Plantae Japonicae*, ex Herb. T. Koyama, no. 170) (DAOM 38 522).
Japan: Honshu, Hiroshima Pref., Yashida-cho, 9 May 1959, leg. Y. Morimoto (DAOM 63 672) (see the note a little further down).
- On *Carex tenuinervis* Ohwi:
Japan: Kyushu, Miyazaki Pref., Kobayashi-shi, 5 Jun 1952, leg. ? (as *Carex leucochlora* Bunge, TSH, sine num.) (pl. rev.).

Known hosts — On *Cyperaceae*: *Carex* sect. *Mitratae*: *Carex alterniflora* var. *alterniflora*, *C. duvaliana*, *C. fernaldiana*, *C. stenostachys* var. *cuneata*, *C. stenostachys* s. lat., *C. tenuinervis*, and (?) *C. pisiformis* var. *pisiformis*.

General distribution. Asia: Japan.

Comments — As observed by Kukkonen (1963: 56), the original description of this species is inadequate: ‘spores strongly angular, mainly 4–6-sided, $15\text{--}23 \times 13\text{--}19 \mu\text{m}$; distinguishable largely on the basis of the relatively small sori; on *Carex remota* in Japan’. In fact, *A. microsora* possesses sori with length falling within the sorus length ranges of many species of *Anthracoidea*; and consequently, this character has no diagnostic value. Additionally, the host identification, given by Sydow (1924), is wrong. Emmended descriptions were given by Kukkonen (1963: 55), and recently, by Denchev & Minter (2010e).

The spore shape of *A. microsora* is predominantly irregular or angular, and this is characteristic especially for the specimens on *Carex alterniflora* var. *alterniflora* and *C. fernaldiana*.

In all specimens of *A. microsora* that we examined, the internal swellings of the spore wall were common and clearly visible, usually 2–3. The warts on the spore wall were larger than those of *A. caryophylleae* as seen by LM. The majority of spores of *A. microsora* had warts that were distinct and affected the spore profile.

It is worth noting that internal swellings of the spores were rarely observed in one of the specimens on *Carex stenostachys* (Hiroshima Pref., Yashida-cho, DAOM 63 672), and when observed, they were only 1–2 in number and low. For now, we retain this specimen as *A. microsora*, but collection of new material is needed.

The spores of *A. microsora* are smaller than those of *A. blepharicarpae* (see the comments to *A. blepharicarpae*). The spore sizes of the examined specimens are given in Table 10.

Table 10. Morphometric variability of spores of *Anthracoidea microsora*

Hosts / specimens	Length	Width	$M \pm 1\sigma$	n
On <i>Carex alterniflora</i> var. <i>alterniflora</i>				
Japan: Honshu, Aomori Pref., Chinnbaya (TNS-F)	16.0–23.5	14.5–21.5	$19.4 \pm 1.6 \times$ 17.0 ± 1.4	50
Japan: Honshu, Aomori Pref., Mt. Iwaki (Vánky, <i>Ustilaginales</i> , no. 1312)	16.0–24.5	13.0–22.0	$20.5 \pm 1.8 \times$ 17.7 ± 1.6	50
Japan: Honshu, Niigata Pref., Shigekurayama (TNS-F)	15.5–22.5	13.5–19.0	$18.8 \pm 1.4 \times$ 16.2 ± 1.4	50
Japan: Honshu, Ibaraki Pref., Ryujin valley (TSH)	15.5–23.0	13.5–19.0	$18.9 \pm 1.6 \times$ 15.9 ± 1.3	50
Japan: Honshu, Tottori Pref., Tottori (TSH)	17.0–23.5	13.5–19.0	$19.4 \pm 1.5 \times$ 16.5 ± 1.2	50
Japan: Shikoku, Kochi Pref., Tosayamamura, Nakagiri (SAPA)	15.5–23.5	13.5–21.0	$19.5 \pm 1.9 \times$ 16.6 ± 1.6	50

Table 10. (continued)

Hosts / specimens	Length	Width	M $\pm$ 1 σ	n
Japan: Shikoku, Kochi Pref., Tosa (TNS-F 230 004)	17.0–24.5	15.5–20.0	20.3 $\pm$ 1.4 $\times$ 17.7 $\pm$ 1.2	50
Japan: Shikoku, Kochi Pref., Taisenji (as <i>C. multiflora</i> , SAPA)	16.5–22.5	14.0–19.0	19.1 $\pm$ 1.3 $\times$ 16.5 $\pm$ 1.4	50
On <i>Carex duvaliana</i>				
Japan: Honshu, Shizuoka Pref., Uri-toge (DAOM 38 525)	17.0–26.5	14.0–20.5	21.3 $\pm$ 2.1 $\times$ 17.2 $\pm$ 1.4	100
On <i>Carex fernaldiana</i>				
Japan: Honshu, Tochigi Pref., Nikko (TNS-F 230 009)	16.5–23.0	14.0–19.0	19.0 $\pm$ 1.4 $\times$ 16.7 $\pm$ 1.0	50
Japan: Honshu, Nagano Pref., Nobeyama (no. 9963)	15.0–23.0	13.0–20.0	19.6 $\pm$ 1.9 $\times$ 16.7 $\pm$ 1.7	50
Japan: Shikoku, Kochi Pref., Makinoyama-mura (SAPA)	16.0–23.5	13.5–19.5	19.7 $\pm$ 1.9 $\times$ 16.9 $\pm$ 1.5	50
On <i>Carex stenostachys</i> var. <i>cuneata</i>				
Japan: Honshu, Iwate Pref., Minamiiwate-gun (SAPA)	15.5–24.0	13.0–19.0	19.8 $\pm$ 1.7 $\times$ 15.9 $\pm$ 1.3	50
On <i>Carex stenostachys</i> s. lat.				
Japan: Honshu, Kyoto-fu, Kibune, north of Kyoto (DAOM 38 522)	16.5–23.0	13.0–20.5	19.6 $\pm$ 1.5 $\times$ 16.2 $\pm$ 1.8	50
Japan: Honshu, Hiroshima Pref., Yashida-cho (DAOM 63 672)	15.0–24.0	13.0–20.0	20.0 $\pm$ 1.5 $\times$ 17.0 $\pm$ 1.4	50
On <i>Carex tenuinervis</i>				
Japan: Kyushu, Miyazaki Pref., Kobayashi-shi (TSH)	16.5–25.5	14.0–20.5	19.7 $\pm$ 1.8 $\times$ 17.0 $\pm$ 1.4	50

Kukkonen (1963: 55–56) listed four sedges as hosts of *A. microsora*: *Carex duvaliana*, *C. conica*, *C. foliosissima*, and *C. stenostachys*, and these hosts were accepted by subsequent authors (Kakishima 1982; Denchev & Minter 2010e; Katumoto 2010; Vánky 2011a). Our revision of the specimens studied by Kukkonen (1963: 56), kept at DAOM, resulted in confirmation of only two sedges, *C. duvaliana* and *C. stenostachys*, as host plants of *A. microsora*. The smut fungi on *Carex conica* and *C. foliosissima* are different from *Anthracoidea microsora*.

The spores of *Anthracoidea* on *Carex foliosissima* in DAOM 38 521 do not possess the typical ornamentation of *A. microsora* (see the comments for *Anthracoidea* sp. on *Carex foliosissima*, after the comments about *A. caryophylleae*), which is why *C. foliosissima* must be excluded from the hosts of *A. microsora*.

The spores of five specimens on *Carex conica* from Hokkaido and Honshu (including the specimen, identified by Kukkonen 1963 as *A. microsora*) possess ornamentation with higher warts than those of *A. caryophylleae*, but lower than those of *A. microsora*. Furthermore, the spore warts of these specimens did not affect the spore profile. Considering the limited number of characters with diagnostic value for *Anthracoidea* species, a reliable identification or establishment of a new taxon is very difficult in this case. A similar conclusion can be made about the spore ornamentation of one specimen on *C. dolichostachya* var. *glaberrima*, two specimens on *C. mitrata*, and one specimen on *C. alterniflora* var. *fulva*, which are listed below. The established data about their spore morphometric variability is given in Table 11. These specimens cannot be referred to a particular species of *Anthracoidea*. They are considered here as belonging to *Anthracoidea* sp. The clarification of the taxonomic status of the Japanese *Anthracoidea* spp. on *Carex conica*, *C. dolichostachya* var. *glaberrima*, *C. mitrata*, and *C. alterniflora* var. *fulva* needs collection of new material and further examination.

Specimens examined.

On *Carex alterniflora* var. *fulva* Ohwi (*C. sachalinensis* var. *fulva* (Ohwi) Ohwi):

Japan: Honshu, Yamanashi Pref., Mt. Fuji, Shoji 2 gome, 16 Jul 1962, leg. N. Hiratsuka & S. Sato (as *Cintractia* sp. on *Carex sachalinensis*, TSH, sine num.) (pl. rev.).

On *Carex conica* Boott:

Japan: Hokkaido, Sapporo-shi, Mt. Kamui, 26 Jul 1931, Y. Imai (as *Cintractia caricis*, SAPA) (pl. rev.).

Japan: Hokkaido, Sapporo-shi, Makomanai, 25 Jun 1933, Y. Homma (as *Cintractia caricis*, SAPA) (pl. rev.).

Japan: Hokkaido, 25 Jun 1933, Y. Hiratsuka (as *Cintractia caricis*, TNS-F 214 875) (pl. rev.).

Japan: Honshu, Ibaraki Pref., Ryujin valley, 1978, N. Hirai et al. (TSH) (pl. rev.).

Japan: Honshu, Shizuoka Pref., Uri-toge, 11 May 1953, leg. T. Koyama, det. D.B.O. Savile (in Kukkonen 1963: 56, as *Anthracoidea microsora*) (DAOM 38 524).

On *Carex dolichostachya* var. *glaberrima* (Ohwi) T. Koyama:

Japan: Honshu, Yamanashi Pref., Minami-koma-gun, Hayakawa-choo, Narata, 22 May 1976, leg. M. Furuse, no. 11 017 (ex K, sine num.) (pl. rev.).

On *Carex mitrata* Franch.:

Japan: Shikoku, Kochi Pref., Tosa, Jinzenji, 19 Apr 1937, T. Yoshinaga (as *Cintractia caricis* on *Carex tristachya* Thunb., TNS-F 230 005) (pl. rev.); ditto, 19 Apr 1937, T. Yoshinaga (as *C. caricis* on *Carex multifolia* Ohwi, TNS-F 230 006) (pl. rev.).

Table 11. Morphometric variability of spores of *Anthracoidea* spp. on selected species in *Carex* sect. *Mitratae*

Hosts / specimens	Length	Width	M ± 1σ	n
<i>On Carex alterniflora</i> var. <i>fulva</i>				
Japan: Honshu, Yamanashi Pref., Mt Fuji (TSH)	16.5–25.5	14.0–20.5	19.7 ± 1.8 × 17.0 ± 1.4	50
<i>On Carex conica</i>				
Japan: Hokkaido, Sapporo-shi, Mt. Kamui (SAPA)	16.0–23.0	14.0–20.5	19.8 ± 1.5 × 17.2 ± 1.3	50
Japan: Hokkaido, Sapporo-shi, Makomanai (SAPA)	17.5–25.0	14.0–21.5	20.7 ± 1.8 × 17.9 ± 1.7	50
Japan: Honshu, Ibaraki Pref., Ryujin valley (TSH)	16.5–22.5	14.0–18.5	19.4 ± 1.4 × 16.4 ± 1.1	50
Japan: Honshu, Shizuoka Pref., Uritoge (DAOM 38 524)	16.0–24.0	13.0–18.5	19.7 ± 1.6 × 15.8 ± 1.6	50
<i>On Carex dolichostachya</i> var. <i>glaberrima</i>				
Japan: Honshu, Yamanashi Pref., Narata (K)	16.0–22.0	13.0–20.5	18.9 ± 1.3 × 16.3 ± 1.7	50
<i>On Carex mitrata</i>				
Japan: Shikoku, Kochi Pref., Tosa, Jinzenji (TNS-F 230 005)	15.0–24.5	13.5–21.0	20.0 ± 1.8 × 16.3 ± 1.7	50

All host plants of *A. microsora* are East Asian species if not endemics to Japan. *Carex duvaliana* occurs in Japan (Honshu, Shikoku, and Kyushu) and SE China, while *C. fernaldiana* is distributed in Japan (Hokkaido, Honshu, Shikoku, and Kyushu), Korea, and Taiwan. The remaining three sedges are endemic to Japan: *C. alterniflora* var. *alterniflora* (known from Honshu and Kyushu), *C. stenostachys* (with its three varieties known from Honshu), and *C. tenuinervis* (Shikoku and Kyushu).

Anthracoidea microsora is regarded as endemic to Japan.

Further, Hirata & Yuji (1979) reported five specimens of ‘*Cintractia caricis*’ from Kyushu on three host plants: *Carex dolichostachya* var. *glaberrima*, *C. pisiformis* var. *sikokiana* (Franch. & Sav.) T. Koyama (as *C. sachalinensis* var. *sikokiana* (Franch. & Sav.) Ohwi), and *C. mitrata* var. *aristata*. We have not revised these specimens and cannot comment their taxonomic status.

Akahori (2011) reported ‘*Anthracoidea caricis*’ on *Carex pisiformis* Boott var. *pisiformis* from Kanagawa Pref. The manuscript of this work was already completed when we received

the specimen on which this record was based. This specimen will be discussed in a separate communication.

Lit.: Sydow (1924), Kukkonen (1963), Kakishima (1982), Denchev & Minter (2010e), Katumoto (2010), Vánky (2011a).

On sect. *Paniccae*

Anthracoidea laxae Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 90, 1963. — Holotype on *Carex laxa*, Finland, Ostrobothnia borealis, Haukipudas, Kello, Nurmeslehto, Haravasuo, 7 Jul 1951, E. Pallari (TUR); isotypes in Fungi exsic. fenn., no. 287.

Literature records (specimens not seen).

On *Carex laxa* Wahlenb.:

South Kuriles: Shikotan (Karatygin et al. 1983; Karatygin & Azbukina 1989; Govorova 1990; Azbukina et al. 1995).

Anthracoidea paniccae Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 76, 1963. — Holotype on *Carex panicca*, Finland, Ahvenanmaa [Åland], Kökar, Idö, 4 Aug 1947, L.E. Kari (TUR); isotypes in Fungi exsic. fenn., no. 129.

Figs 117–120

Sori in ovaries, scattered in the inflorescence, as black, hard bodies, 2–3 mm long, when young covered by a membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** slightly flattened, in plane view slightly irregular, broadly elliptical or suborbicular in outline, sometimes slightly angular, in plane view $18\text{--}27.5 \times 14\text{--}24$ ($22.2 \pm 2.0 \times 19.4 \pm 2.0$) μm ($n/1 = 50$), in side view 11–14 μm thick, dark to very dark reddish brown; wall uneven, 1–2.5 μm wide, internal swellings hardly visible, light-refractive areas lacking; minutely verruculose, warts low (up to 0.3 μm). In SEM punctate between the warts; warts often forming small groups or short rows. **Spore germination** of *Proceres*-type (Kukkonen 1963), resulting in a two-celled basidium, 200–300 μm long, the apical cell 60–80 μm long and 4–6.5 μm thick; basidiospores cylindrical, rod-shaped, straight or slightly curved, rounded at the ends, $(30\text{--})40\text{--}98(104) \times 2\text{--}6$ μm .

Hosts — On *Cyperaceae*: *Carex* sect. *Paniccae*: *Carex livida* (Wahlenb.) Willd., *C. vaginata* Tausch var. *vaginata* (*C. vaginata* subsp. *quasivaginata* (C.B. Clarke) Malyshev), *C. vaginata* var. *petersii* (C.A. Mey. ex Schmidt) Akiyama (*C. falcata* Turcz.).

Distribution within the studied area — On *C. livida*, North Kuriles (Paramushir); on *C. vaginata* var. *vaginata*, Sakhalin; on *C. vaginata* var. *petersii*, North Kuriles (Shumshu, Paramushir).

Specimen examined.

On *Carex vaginata* Tausch var. *vaginata*:

Russia: S. Sakhalin, Shikka, Higashi-Taraika, 23 Jul 1930, leg. H. Ôtani & Y. Imai (as *Cintractia caricis*, SAPA, sine num.) (pl. rev.).

Literature records.

On *Carex livida* (Wahlenb.) Willd.:

North Kuriles: Paramushir (Govorova 1990; Azbukina et al. 1995).

On *Carex vaginata* var. *petersii* (C.A. Mey. ex Schmidt) Akiyama:

North Kuriles: Shumshu, Paramushir (as *Carex falcata* Turcz., Azbukina et al. 1995).

Known hosts — On *Cyperaceae*: *Carex* sect. *Paniceae*: *Carex livida*, *C. panicea* L. (principal host), *C. vaginata* var. *vaginata* (principal host), *C. vaginata* var. *petersii*.

General distribution. **Asia:** China, Russia (West Siberia, Far East). **Europe:** Austria, Czech Republic, Denmark, Estonia, Faeroes, Finland, Germany, Iceland, Italy, Latvia, Lithuania, Norway, Poland, Romania, Russia, Slovakia, Spain, Sweden, Switzerland, UK, Ukraine. **North America:** Canada, USA, Greenland.

Comments — *Anthracoidea paniceae* on *Carex vaginata* var. *petersii* (as *C. falcata*) was reported as distributed in the South Kuriles (Kunashir; Govorova 1987, 1990). However, this record was not considered by Azbukina et al. (1995), most likely due to misidentification of the host.

In Japan, *Anthracoidea paniceae* on *Carex vaginata* was reported by Nannfeldt (1979: 30), based on a record of *Cintractia caricis* in Zundel (1953: 24; wrongly cited by Nannfeldt as '21'). Obviously, the initial source of that record is Ito (1936: 68; as *Cintractia caricis* on *Carex vaginata*). However, it is a record from Sakhalin (based on the abovementioned specimen kept at SAPA). This specimen has remained unnoticed by Russian mycologists (comp. Govorova 1987, 1990; Azbukina et al. 1995). *Anthracoidea paniceae* should be added to the list of smut fungi in Sakhalin.

In the literature, an additional sedge in section *Racemosae* (as *Atratae*), *C. bicolor* All., is reported as a host of *Anthracoidea paniceae* (Vánky 1994, 2011b), based on the host range treatment of Kukkonen (1963: 77–78).

Kukkonen (1963: 77) and Nannfeldt (1979: 30) discussed *Carex bicolor* as a species of doubtful affinity. Egorova (1999) included this species in *C. sect. Microrhynchae*, in a monotypic subsection, *Bicolores* Kük. Ball (2002) treated *C. bicolor* as a member (and a type species) of *C. sect. Bicolores* (L.H. Bailey) Rouy, defined as 'a small apparently natural section of uncertain relationships'. This section includes four species. The separation of section *Bicolores* from section *Racemosae* was supported by the results of Hendrichs et al. (2004). Another host plant of *A. paniceae*, *Carex aurea* Nutt., assigned by Vánky (2011a) to section *Paniceae*, also belongs to section *Bicolores*. The recorded specimens of *Anthracoidea* on *Carex bicolor* and *C. aurea* need critical re-examination.

Another problem is the close affinity of *Carex pilosa* (*C. sect. Depauperatae*; a type host of *A. pilosae*) with sedges from *C. sect. Paniceae* (Hendrichs et al. 2004) – see the comments under *A. pilosae*.

Lit.: Ito (1936), Kukkonen (1963), Nannfeldt (1979), Azbukina & Khavkina (1984), Govorova (1987, 1990), Azbukina et al. (1995), Katumoto (2010), Denchev & Minter (2011f), Vánky (2011a).

On sect. *Phacocystis* (*Acutae*)

Anthracoidea heterospora (B. Lindeb.) Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 63, 1963. — *Cintractia heterospora* B. Lindeb., in Nannfeldt & Lindeberg, Svensk Botanisk Tidskrift 51: 500, 1957. — *C. variabilis* Lehtola, Acta Agralia Fennica 42: 45, 1940 (later homonym), non *C. variabilis* S. Ito, 1935. — Lectotype on *Carex nigra*, Finland, Nyland, Tikkurila, 1915, E. Kitunen (design. by Nannfeldt & Lindeberg 1957: 500); isolectotypes in Mycoth. fenn., no. 36/a.

Figs 121–124

Spores flattened, in plane view suborbicular, broadly elliptical or irregular in outline, in plane view $15\text{--}21\text{--}22.5 \times 13\text{--}18\text{--}19$ ($18.3 \pm 1.7 \times 16.3 \pm 1.4$) μm ($n/1 = 50$), in side view $9.5\text{--}12.5$ μm thick, light to middle reddish brown; wall slightly uneven, $1.0\text{--}2.2$ μm thick, thicker at the angles, 1–3 internal swellings present, light refractive areas and protuberances absent; minutely verruculose, warts up to 0.2 μm high, not affecting the spore profile.

Host — On *Cyperaceae*: *Carex* sect. *Phacocystis*: *Carex cespitosa* L.

Distribution within the studied area — On *C. cespitosa*, Russia (Sakhalin).

Specimen examined.

On *Carex cespitosa* L.:

Russia: Sakhalin, Jimutaki, 24 Jul 1906, leg. K. Miyabe & T. Miyagi (as *Cintractia variabilis*, SAPA) (pl. rev.). This specimen is a paratype of *Cintractia variabilis* – see the notes to *Anthracoidea variabilis*.

Known hosts — On *Cyperaceae*: *Carex* sect. *Phacocystis*: *Carex acuta* L., *C. andersonii* Boott, *C. angustata* Boott, *C. aquatilis* Wahlenb. var. *aquatilis*, *C. aquatilis* var. *minor* Boott (*C. concolor* R. Br.), *C. aquatilis* var. *dives* (Holm) Kük. (*C. sitchensis* J.D. Prescott ex Bong.), *C. bigelowii* subsp. *ensifolia* (Turcz. ex Gorodkov) Holub, *C. cespitosa*, *C. decidua* Boott, *C. elata* All. subsp. *elata*, *C. elata* subsp. *omskiana* (Meinsh.) Jalas (*C. omskiana* Meinsh.), *C. gaudichaudiana* Kunth, *C. haydenii* Dewey, *C. juncella* (Fr.) Th. Fr., *C. lenticularis* Michx., *C. lugens* H.T. Holm, *C. nigra* (L.) Reichard, *C. orbicularis* Boott, *C. schmidtii* Meinsh., *C. stricta* Lam., *C. subdola* Boott, *C. trinervis* Degl., *C. thunbergii* Steud. (*C. appendiculata* (Trautv. & C.A. Mey.) Kük.). Species of *Carex* from sections *Temnemis* and *Tuminenses* are also recorded as hosts.

General distribution. Asia (China, Mongolia, Russia – Arctic region, Far East), Europe, North and South America, Australia, and New Zealand.

Comments — As a host plant of *A. heterospora*, *Carex cespitosa* is reported here for the first time from the Far East of Russia.

Lit.: Ito (1935, 1936).

On sect. *Racemosae*

Anthracoidea buxbaumii Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 88, 1963. — Holotype on *Carex buxbaumii*, Finland, Kuusamo, Liikasenvaara, Kuivajärvi, 8 Aug 1948, L.E. Kari (TUR); isotypes in Fungi exsic. fenn., no. 126. **Figs 125–128**

Sori in ovaries, scattered in the inflorescence, as subglobose or broadly ellipsoidal, black, hard bodies, 2–4 mm long, when young covered by a thin, whitish membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view slightly irregular, suborbicular or broadly elliptical in outline, in plane view $21.5\text{--}30 \times 18\text{--}25$ ($25.3 \pm 1.8 \times 22.7 \pm 1.5$) μm ($n/1 = 50$), in side view $12.5\text{--}16.5$ μm thick, very dark reddish brown; wall even to slightly uneven, $1.5\text{--}3.5$ μm thick, with 1–3 internal swellings, light-refractive areas and protuberances lacking; minutely verruculose, warts up to 0.3 μm high. In SEM warts often forming small groups or short rows. **Spore germination** of *Proceres*-type (Kukkonen 1963), resulting in a two-celled basidium, $250\text{--}300$ μm long, the apical cell $60\text{--}75$ μm long and $4.5\text{--}5$ μm thick; producing one basidiospore on each cell; basidiospores cylindrical, straight or slightly curved, $42\text{--}92(98) \times 3\text{--}6$ μm .

Hosts — On *Cyperaceae*: *Carex* sect. *Racemosae*: *Carex buxbaumii* Wahlenb., *C. gmelinii* Hook. & Arn.

Distribution within the studied area — On *C. buxbaumii*, Japan (Hokkaido); on *C. gmelinii*, Japan (Hokkaido), South Kuriles (Kunashir).

Specimens examined.

On *Carex buxbaumii* Wahlenb.:

Japan: Hokkaido, Muroran-shi, Numanohata, 8 Jul 1907, M. Kasai (a paratype of *Cintractia subglobosa* S. Ito, SAPA) (pl. rev.).

On *Carex gmelinii* Hook. & Arn.:

Japan: Hokkaido, Kushiro-shi, Atsukeshi-gun, Hamanaka-choo, see-side Hamanaka, 13 Jul 1975, leg. M. Furuse, no. 9087 (K, sine num.).

Literature records (specimens not seen).

On *Carex gmelinii*:

South Kuriles: Kunashir (Govorova 1987, 1990; Azbukina et al. 1995).

Known hosts — On *Cyperaceae*: *Carex* sect. *Racemosae* (syn.: *C. sect. Atratae*; *C. sect. Microrhynchae*): *Carex adelostoma* V.I. Krecz. (*C. buxbaumii* subsp. *alpina* (Hartm.) Liro) (principal host), *C. buxbaumii* (principal host), *C. gmelinii*, *C. hartmanii* Cajander.

General distribution. **Asia:** Japan, Russia (West Siberia, Far East). **Europe:** Estonia, Finland, Lithuania, Norway, Poland, Romania, Russia (Arctic region), Slovakia, Sweden, Switzerland, (?) Ukraine. **North America:** Canada, USA (Alaska).

Comments — *Carex buxbaumii* and *C. gmelinii* belong to *Carex* sect. *Racemosae* G. Don, a large section within *Carex* with about 62 species in extra-tropical regions of Eurasia and North America (Egorova 1999; Murray 2002a; Dai et al. 2010). This section has commonly been named as *Atratae* (Heuffel) H. Christ (e.g., in Flora Europaea, Chater

1980) in the literature when reporting *Anthracoidea* hosts (e.g., Nannfeldt 1979; Vánky 1994; 2011a). Egorova (1999) displaced the name *Atratae* with *Microrhynchae* Drejer ex L.H. Bailey. Currently, *Racemosae* is recognized as the earliest valid name (Murray 2002a; Dai et al. 2010).

The following nine *Carex* species of section *Racemosae* have been previously found to be infected by *Anthracoidea* species: *C. adelostoma*, *C. atrata* L., *C. buxbaumii*, *C. gmelinii*, *C. hartmanii*, *C. heteroneura* S. Watson, *C. norvegica* Retz., *C. raynoldsii* Dewey, and *C. tarumensis* Franch. (Denchev & Denchev 2013).

Some sedges in the former section *Atratae* are currently separated in the *C.* sect. *Scitae* Kük. (Egorova 1999; Murray 2002b). The members of that section are morphologically closely related to the species in *C.* sect. *Racemosae*. The following six *Carex* species of *C.* sect. *Scitae* are known as hosts of *Anthracoidea* species: *C. flavocuspis* subsp. *krascheninnikovii* (Kom. ex V.I. Krecz.) T.V. Egorova, *C. macrochaeta* C.A. Mey., *C. nesophila* Holm, *C. riishirensis* Franch. (incl. *C. koraginensis* Meinsh.), *C. podocarpa* R. Br. (incl. *C. montanensis* L.H. Bailey), and *C. spectabilis* Dewey.

Three *Anthracoidea* species are described on sedges in sections *Racemosae* and *Scitae*: *A. atratae* (Savile) Kukkonen, *A. buxbaumii*, and *A. savilei* Denchev & T. Denchev. *Anthracoidea atratae* differs from *A. savilei* and *A. buxbaumii* by having verrucose spores with higher warts (up to 0.7 µm), compared with the minutely verruculose spores of the other two species, with warts ≤0.3 µm high. *Anthracoidea buxbaumii* differs from *A. savilei* by having larger spores (19–28(–30) µm long) and evenly to slightly unevenly thickened spore walls while the latter species possesses spores (15–)16–21.5 µm long and unevenly thickened spore walls (Denchev & Denchev 2013).

The description in the current treatment is based on a study of the Japanese specimen on *Carex gmelinii*. This specimen matches the original description of *A. buxbaumii* (Kukkonen 1963). The spores of that Japanese specimen of *A. buxbaumii* possess even to slightly uneven walls which not only fit the original description, but also correspond to the spore wall of comparative European specimens on the same host (e.g., Norway, Sör-Tröndelag, pr. oppid. Röros, 62°36' N, 11°30' E, alt. 700 m, 17 Sep 1989, K. Vánky, no. 3371, Vánky, *Ustilag. exsic.*, no. 726).

The other examined specimen from Japan, the one on *Carex buxbaumii*, is a paratype of *Cintractia subglobosa* S. Ito (Ito 1935: 92). The last name is a synonym of *Anthracoidea limosa*, as it was noted. Two specimens are listed in the protologue of *C. subglobosa*: a holotype (on *Carex limosa* var. *fuscocuprea*) and paratype (on *C. buxbaumii*). The paratype was considered by Nannfeldt (1979: 16) as *Anthracoidea buxbaumii*. Vánky & Harada (1990: 448) assumed that this decision had been taken without a revision but based just on its host specialization.

The principal host of *Anthracoidea buxbaumii* is *Carex buxbaumii*, a circumboreal species with a disjunct distribution. It occurs from Europe to East Siberia and in East Asia and North America. There are different views regarding the distribution of this sedge in Asia. Some authors (e.g. Egorova 1999) considered it distributed from Europe eastward to East Siberia and the Aral-Caspian Region. Other authors (e.g., Ohwi 1965; Popov 1970; Govaerts et al. 2007; Hoshino et al. 2011) considered it also distributed in East Asia –

the South Kuriles, Hokkaido, Honshu (Nagano Pref.), and the Korean Peninsula. Most likely, according to the first point of view, Nannfeldt (1979) treated the host plant of the paratype of *Cintractia subglobosa* as *Carex tarumensis* Franch., without any explanation, and as it seems, without a revision of a specimen. *Carex tarumensis* is closely related to *C. buxbaumii*, and distributed in Sakhalin, South Kuriles, Hokkaido, the Korean Peninsula, and NE China. Vánky & Harada (1990: 448) accepted Nannfeldt's correction and cited the specimen as "*C. 'buxbaumii'* (= *C. tarumensis* Franch.)". In the recently published world monograph of the smut fungi (Vánky 2011a: 24), *Carex tarumensis* is still listed as a host of *A. buxbaumii*. A revision of that host plant, made by one of us (M.M.) for the purposes of the current study, proved that the initial identification, as *Carex buxbaumii*, had been correct and that *C. tarumensis* is not a host of *A. buxbaumii*.

A description of the paratype of *Cintractia subglobosa* on *Carex buxbaumii* is impossible because that specimen is too scarce and represented by a fragment of a single sorus. All that can be stated is that there is a specimen of *Anthracoidea* on *Carex buxbaumii* from Japan but we can neither confirm nor doubt that this is exactly *A. buxbaumii*. Re-collection and re-examination are needed.

The smut fungus on *Carex buxbaumii* is distributed mainly in North Europe (Sweden, Norway, Finland, and Arctic European Russia) and Canada (Kukkonen 1963; Nannfeldt 1979; Karatygin 1982; Parmelee 1983, 1988; Scholler et al. 2003; Denchev & Minter 2010a). Isolated localities are known from Central Europe (Switzerland – Kemler et al. 2007, and Poland – Piątek & Mułenko 2010). The second principal host, *Carex adelostoma*, has predominantly subarctic distribution. As infected by *A. buxbaumii*, it is reported from North Europe (Sweden, Norway, and Finland) and Canada (Nannfeldt 1979; Denchev & Minter 2010a). It seems that in Sweden, Norway, Finland, and Arctic European Russia *A. buxbaumii* is common on both principal hosts (*Carex adelostoma* and *C. buxbaumii*) (Kukkonen 1963). Similarly, for Canada it is known on *C. buxbaumii* from British Columbia to Newfoundland (Parmelee 1983).

The third host, *Carex hartmanii*, is distributed in Europe, Caucasus, NE Turkey, West Siberia to Central Asia. On this host plant, *A. buxbaumii* is known from single localities in Sweden (Nannfeldt 1979), Central Europe (Poland, Slovakia, and Romania – Vánky 1985a; Paulech 1998; Piątek et al. 2005), and (?) Ukraine (Savchenko & Heluta 2012). A single Hungarian record is reported by Kukkonen (1963: 89) and Nannfeldt (1979: 16) but currently that locality is in Romania (cf. Vánky 1985a: 19). In Central Europe, certainly *A. buxbaumii* is a rare species known on *Carex hartmanii* (and exceptionally on *C. buxbaumii*, from two localities). The Ukrainian specimen on *Carex hartmanii* was not examined by us, but the published spore measurements, $(17-18-22(-23) \times (12-13-20(20.4 \pm 2.5 \times 16.3 \pm 2.1) \mu\text{m}$ (Savchenko & Heluta 2012), do not correspond to those typical for the spores of *A. buxbaumii*.

The records of *Anthracoidea buxbaumii* from East Asia are too limited. There, it is known only on *Carex gmelinii*. This sedge is an Asiatic-North American species, with an Amphipacific distribution. It occurs in East Asia (Far East of Russia, Sakhalin, Kuriles, Japan – Hokkaido and Aomori Pref., and N. Korea) and North America (Alaska and British Columbia). As infected by *A. buxbaumii*, it has been previously reported only from

Kamchatka (Azbukina & Khavkina 1984; Govorova 1990; Azbukina et al. 1995) and Kunashir Island (Govorova 1987, 1990; Azbukina et al. 1995). Thus we report here the third occurrence of *A. buxbaumii* on *Carex gmelinii*. At the same time, it is a new fungus-host combination for Japan.

Lit.: Ito (1935), Nannfeldt (1979), Azbukina & Khavkina (1984), Govorova (1987, 1990), Vánky & Harada (1990), Azbukina et al. (1995), Denchev & Minter (2010a), Katumoto (2010), Vánky (2011a), Denchev & Denchev (2013).

On sect. *Scitae*

Anthracoidea atratae (Savile) Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 80, 1963. — *Cintractia atratae* Savile, Canadian Journal of Botany 30: 423, 1952. — Holotype on *Carex atrata*, USA, Montana, Glacier National Park, Grinnel Lake, 27 Aug 1915, E.T. Bartholomew (DAOM); isotypes in Bartholomew, Fungi columb., no. 4908.

Literature records (specimens not seen).

On *Carex flavocuspis* subsp. *krascheninnikovii* (Kom. ex V.I. Krecz.) T.V. Egorova (*C. krascheninnikovii* Kom. ex V.I. Krecz.):

North Kuriles: Paramushir (Govorova 1990; Azbukina et al. 1995).

On *Carex nesophila* Holm (*C. microchaeta* subsp. *nesophila* (Holm) D.F. Murray):

North Kuriles: Paramushir (as *Carex nesophila* Holm; Govorova 1990; Azbukina et al. 1995).

On *Carex podocarpa* R. Br.:

North Kuriles: Paramushir (Govorova 1990; Azbukina et al. 1995).

On sect. *Siderostictae*

Anthracoidea siderostictae Kukkonen, Annales Botanici Fennici 1: 174, 1964. — Holotype on *Carex siderosticta*, Japan, Honshu, Nagano Pref., Nobeyama, 18 Jun 1948, Shibuya et al. (ZT); isotype TSH S223!

Figs 129–132

(for additional illustrations of the isotype, see Denchev & Minter 2011i: Figs A–D)

Sori in ovaries, scattered in the inflorescence, as subglobose to ellipsoidal or ovoid, black, hard bodies, 1.5–3.5 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view mainly suborbicular, oval or broadly elliptical, sometimes elliptical or slightly irregular in outline, in plane view $17\text{--}24.5 \times 14.5\text{--}21$ ($20.3 \pm 1.2 \times 18.2 \pm 1.1$) μm ($n/4 = 200$), in side view $11.5\text{--}14.5$ μm thick, yellowish brown, often covered by remnants of the gelatinous sheath; wall evenly thickened, $0.9\text{--}1.5$ ($\text{--}2$) μm thick, protuberances, internal swellings, and light-refractive spots lacking; verrucose to coarsely verrucose, ornamented with rounded warts or with large, irregular, apically flattened projections; the ornaments $0.5\text{--}1.2$ μm high, strongly irregularly arranged, conspicuously affecting the spore profile.

In SEM warts isolated or forming small groups, sometimes confluent or arranged into short, irregular rows; the wall between the warts finely and irregularly punctate. **Spore germination** unknown.

Hosts — On *Cyperaceae*: *Carex* sect. *Siderostictae*: *Carex ciliatomarginata* Nakai, *C. siderosticta* Hance.

Distribution within the studied area — On *C. ciliatomarginata*, Japan (Honshu, Shikoku); on *C. siderosticta*, Japan (Hokkaido, Honshu, Shikoku), South Korea (Gangwon Prov.).

Specimens examined.

On *Carex ciliatomarginata* Nakai:

Japan: Shikoku, Kochi Pref., Kochishi, Jinzenji, 19 Apr 1937, T. Yoshinaga (as *Cintractia subinclusa*, SAPA) (pl. rev.).

On *Carex siderosticta* Hance:

Japan: Honshu, Iwate Pref., Morioka-shi, 17 Jun 1897, Y. Takahashi (as *Ustilago caricis*, SAPA) (pl. rev.); ditto (as *Ustilago caricis*, TNS-F 229 992) (pl. rev.).

Japan: Honshu, Iwate Pref., Hanamaki, 17 Jun 1931, S. Murai (as *Cintractia subinclusa*, SAPA) (pl. rev.).

Japan: Honshu, Yamagata Pref., Niibori, May 1928, K. Yokowo (as *Cintractia subinclusa*, SAPA) (pl. rev.).

Japan: Honshu, Nagano Pref., Nobeyama, 18 Jun 1948, Shibuya, Shinkai & Hirota (as *Cintractia subinclusa*, TSH S223; **isotype**) (pl. rev.).

Japan: Shikoku, Kochi Pref., Tosa, Jinzenji, 19 Apr 1937, T. Yoshinaga (as *Cintractia subinclusa*, TNS-F 229 997) (pl. rev.).

Japan: Shikoku, Kochi Pref., Kochishi, Jinzenji, 19 Apr 1937, T. Yoshinaga (as *Cintractia subinclusa*, TNS-F 229 999) (pl. rev.).

South Korea: Gangwon Prov., Pyeongchang, Mt. Odae, 30 May 1969, J.S. Kim (SNU 45 285).

Additional specimens (not seen).

On *Carex ciliatomarginata*:

Japan: Honshu, Aichi Pref., Uri-toge, 1953, Koyama (DAOM; n.v.) (Kukkonen 1963: 73, 1964: 175).

On *Carex siderosticta*:

Japan: Hokkaido, Hidaka-machi, Saru, Biratori, Saru-river, Nibutani-dam, 1994, leg. Y. Harada (as *Anthracoidea subinclusa*, HHUF 24 900; n.v.).

Known hosts — On *Cyperaceae*: *Carex* sect. *Siderostictae*: *Carex ciliatomarginata*, *C. siderosticta*.

General distribution. **Asia:** China (Jilin, Shanxi), Japan, Russia (Far East), South Korea.

Comments — There is no discreteness in the morphometric variability of the spore length and width among the studied Japanese and Korean specimens. The spore sizes of the examined specimens are given in Table 12.

Table 12. Morphometric variability of spores of *A. siderostictae*

Hosts / specimens	Length	Width	M ± 1σ	n
On <i>Carex ciliatomarginata</i>				
Japan: Shikoku, Kochi Pref., Kochishi, Jinzenji (SAPA)	19.0–23.5	16.5–21.0	21.2 ± 0.9 × 19.5 ± 1.0	50
On <i>Carex siderosticta</i>				
Japan: Honshu, Iwate Pref., Morioka-shi (SAPA)	17.0–23.0	15.0–21.0	19.8 ± 1.4 × 17.7 ± 1.3	50
Japan: Honshu, Yamagata Pref., Niibori (SAPA)	17.5–21.5	15.5–20.5	19.6 ± 0.8 × 17.8 ± 1.1	50
Korea: Gangwon Prov., Pyeongchang, Mt. Odae (SNU 45 285)	18.0–24.5	14.5–20.0	20.7 ± 1.5 × 17.7 ± 1.1	50

Carex siderosticta is the principal host. It is distributed in the Far East of Russia, Japan (Hokkaido, Honshu, Shikoku, and Kyushu), S. Korea, and China. As infected by *A. siderostictae*, it is known from the Far East of Russia, Japan, and China (Ito 1936; Liro 1938: 260; Ling 1953; Nannfeldt & Lindeberg 1957: 509; Kukkonen 1963: 73, 1964; Azbukina & Khavkina 1984; Govorova 1990; Guo 1994, 2000; Azbukina et al. 1995; Denchev & Minter 2011i). *Anthracoidea siderostictae* is reported here for the first time from South Korea.

The second host, *C. ciliatomarginata*, is distributed in Japan (Honshu, Shikoku, and Kyushu, including Tsushima), Korea, and NE China. Some authors, e.g. Govaerts et al. (2007), Dai et al. (2010) treat this species at variety level, as *C. siderosticta* var. *pilosa* H. Lév. ex T. Koyama. As infected by *Anthracoidea*, *C. ciliatomarginata* is only known from Japan (Honshu and Shikoku).

Anthracoidea siderostictae is a rare species. To the best of our knowledge, it is known from 13 localities on *Carex siderosticta* (from Japan, Far East of Russia, South Korea, and China – Jilin and Shanxi) and two localities on *C. ciliatomarginata* (from Japan) (comp. Denchev & Minter 2011i).

Carex falcata Turcz. (*C. sect. Paniceae*) was erroneously reported by Govorova (1990: 22) as a host plant of *A. siderostictae*; this sedge is a host of *A. paniceae*.

Lit.: Ito (1936, as *A. subinclusa*), Nannfeldt & Lindeberg (1957, as *A. subinclusa*), Kukkonen (1963, 1964), Kakishima (1982, as *A. subinclusa*), Azbukina & Khavkina (1984), Govorova (1990), Azbukina et al. (1995), Katumoto (2010), Denchev & Minter (2011i), Vánky (2011a).

On sect. *Silvaticae*

Anthracoidea arnellii Denchev, T. Denchev & Karatygin, Mycotaxon 114: 68, 2011. — Holotype on *Carex arnellii*, Russia, Altai Republic, the Altai Mts, near Teletskoe Lake, valley of Chiri River, 3 Aug 1985, leg. I.V. Karatygin (LE 68 682!).

Literature record (specimen not seen).

On *Carex arnellii* Christ:

Russia: Sakhalin, Higashi-Taraika, 23 Jul 1930, leg. H. Ôtani & Y. Imai (reported by Kawai & Ôtani 1931: 230, as *Cintractia caricis*).

This record most likely refers to the recently described species, *Anthracoidea arnellii*, as it has been already assumed by Denchev et al. (2011a). Unfortunately, this specimen was not found in the studied dried reference collections in Japan.

Comments — *Anthracoidea arnellii* is known only from West Siberia (the Altai Mts) and Sakhalin. It possesses irregularly polyangular spores with distinct internal swellings similar to *A. capillaris* Kukkonen, but the spores of the latter are smaller. *Anthracoidea capillaris* is known to infect only *Carex capillaris* L. In older taxonomic schemes, *Carex arnellii*, *C. sylvatica* Huds., and *C. capillaris* were included in *Carex* sect. *Strigosae* Christ (Chater 1980). In recent taxonomic schemes (e.g., in Egorova 1999), the three species are treated as members of two different, non-related sections: *C. arnellii* and *C. sylvatica* in *C. sect. Silvaticae*, and *C. capillaris* in *C. sect. Chlorostachyae* Meinsh. (synonyms: *C. sect. Hymenochlaenae* subsect. *Capillares* (Asch. & Graebn.) Kük.; *C. sect. Capillares* (Asch. & Graebn.) Rouy). For *Carex sylvatica* and *C. capillaris*, Hendrichs et al. (2004) found that they 'are neither clustered together nor with any other member of section *Hymenochlaenae*' and that the section *Hymenochlaenae* is heterogeneous. For these reasons, Denchev et al. (2011a) considered *Anthracoidea arnellii*, on a host in *Carex* sect. *Silvaticae*, as a distinct species.

On sect. *Temnemis*

Anthracoidea liroi (Lehtola) Nannf. & B. Lindeb., Svensk Botanisk Tidskrift 59: 205, 1965. — *Cintractia liroi* Lehtola, Acta Agralia Fennica 42(1): 46, 1940. — Neotype on *Carex bigelowii* × *nigra*, Finland, Lapponia enontekiensis, Kilpisjärvi, July 1934, H. Roivainen & J.I. Liro (H.U.V. 158) (design. by Vánky 1990: 274); isoneotypes in Mycoth. fenn., no. 104 (as *Cintractia caricis* on '*Carex rigida*', = *Carex bigelowii* × *nigra*, comp. Nannfeldt & Lindeberg 1965: 206).

Literature records (specimens not seen).

On *Carex middendorffii* F. Schmidt:

North Kuriles: Paramushir (Govorova 1990; Azbukina et al. 1995).

On sect. *Vesicariae*

Anthracoidea subinclusa (Körn.) Bref.

See also the comments to the same smut fungus on *Carex* sect. *Carex*.

Hosts — On *Cyperaceae*: *Carex* sect. *Carex*: *C. miyabei* Franch. (*C. fedia* var. *miyabei* (Franch.) T. Koyama); *Carex* sect. *Vesicariae*: *Carex saxatilis* L.

Distribution within the studied area — On *C. miyabei*, Japan (Hokkaido), *C. saxatilis*, North Kuriles (Paramushir).

Literature records (specimen not seen).

On *Carex saxatilis* L.:

North Kuriles: Paramushir (Govorova 1990; Azbukina et al. 1995).

On *Carex* subgen. *Vignea*

On sect. *Divisae*

Anthracoidea variabilis (S. Ito) Kakish., Memoirs of Institute of Agriculture and Forestry, University of Tsukuba 1: 29, 1982. — *Cintractia variabilis* S. Ito, Transactions of the Sapporo Natural History Society 14: 92, 1935. — Holotype on *Carex arenicola*, Japan: Honshu, Niigata Pref., Uchino, 1 Aug 1930, S. Ito (SAPA, sine num.). **Figs 133–136**

Sori in ovaries, scattered in the inflorescence, as subglobose or ovoid, black, hard bodies, 2–2.5 mm long, when young covered by a thin membrane, later becoming exposed; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view suborbicular, broadly elliptical, orbicular or slightly irregular in outline, in plane view 15–24 × 14–20.5 ($20.0 \pm 1.4 \times 17.8 \pm 1.4$) μm ($n/2 = 150$), in side view 11–13.5 μm thick, dark to very dark reddish brown; wall slightly unevenly thickened, 1.2–3.0(–3.5) μm thick, no protuberances, internal swellings and light-refractive areas lacking; verruculose, warts up to 0.3 μm high, spore profile not affected to slightly affected. **Spore germination** unknown.

Host — On *Cyperaceae*: *Carex* sect. *Divisae*: *Carex arenicola* Fr. Schm.

Distribution within the studied area — On *C. arenicola*, Japan (Honshu), South Kuriles (Kunashir).

Specimens examined.

On *Carex arenicola* F. Schmidt:

Japan: Honshu, Niigata Pref., Uchino, 1 Aug 1930, S. Ito (as *Cintractia variabilis*; holotype, SAPA) (pl. rev.).

Russia: Kuriles, Kunashir, Keramui, 18 Aug 1936, M. Tatewaki (as *Cintractia variabilis*, SAPA) (pl. rev.).

Known host — On *Cyperaceae*: *Carex* sect. *Divisae*: *Carex arenicola*.

General distribution. Asia: Japan, Russia (South Kuriles).

Revised paratypes of *A. variabilis*:

Anthracoidea sp. on *Carex arenicola* F. Schmidt – see Table 13:

Japan: Honshu, Miyagi Pref., Suga, 24 Jun 1931, S. Murai (as *Cintractia variabilis*, SAPA; paratype of *A. variabilis*) (pl. rev.). For the morphology of this specimen, see notes below.

Anthracoidea heterospora on *Carex cespitosa* L.:

Russia: Sakhalin, Jimutaki, 24 Jul 1906, leg. K. Miyabe & T. Miyagi (as *Cintractia variabilis*, SAPA; paratype of *A. variabilis*) (pl. rev.). For the morphology of this specimen, see the description given to *A. heterospora*.

Comments — Three specimens are cited in the protologue (Ito 1935: 92): two of them on *Carex arenicola* (including a specimen, correctly selected as a type), and one on *C. cespitosa*. All of these specimens are kept at SAPA. In the same dried reference collection, another specimen on *C. arenicola* (from the South Kuriles) was also found. The description given here is based on two specimens – the type and that from the S. Kuriles, which are morphologically identical (Table 13).

The paratype on *Carex arenicola* possesses some morphological differences compared to the type and the specimen from the S. Kuriles, namely, the mean values of the spore length and width are discrete ($17.9 \times 15.8 \mu\text{m}$) (see Table 13), and the spore wall is thinner ($1-2.2(-2.5) \mu\text{m}$). The existence of a second *Anthracoidea* species on *C. arenicola* is possible.

Table 13. Morphometric variability of spores of *Anthracoidea* spp. on *Carex arenicola*

Hosts / specimens	Length	Width	M $\pm$ 1 σ	n
<i>Anthracoidea variabilis</i>				
Japan: Honshu, Niigata Pref., Uchino (holotype, SAPA)	17.5–24.0	14.0–20.5	20.4 $\pm$ 1.2 $\times$ 17.8 $\pm$ 1.4	100
Russia: S. Kuriles, Kunashir, Keramui (SAPA)	15.0–24.0	14.0–20.0	19.6 $\pm$ 1.7 $\times$ 17.7 $\pm$ 1.4	50
<i>Anthracoidea</i> sp.				
Japan: Honshu, Miyagi Pref., Suga (paratype, SAPA)	14.5–22.5	12.5–19.0	17.9 $\pm$ 1.5 $\times$ 15.8 $\pm$ 1.4	100

Designation of a lectotype of *A. variabilis* (SAPA, sine num.; isoelectotypes BPI 194 433, H.U.V. 16 664) was proposed by Vánky (2011a: 74). The locality, collection date, and collector name of this lectotype coincide with those of a specimen, unambiguously designated by Ito (1935) as a type. In accordance with Art. 9.19.(a) (Melbourne Code), the lectotype, designated by Vánky (2011a), must be superseded.

Carex arenicola has an Eastern Asiatic distribution. It occurs in the Far East of Russia, Sakhalin, the South Kuriles, Japan (Hokkaido, Honshu, Shikoku, and Kyushu), Korea, and NE China.

Anthracoidea variabilis was known only from Japan and Sakhalin (Ito 1935, 1936) but as it was explained, the specimen from Sakhalin must be referred to *A. heterospora*. This specimen was not discussed by Russian mycologists neither as *A. variabilis* nor as *A.*

heterospora (comp. Azbukina & Khavkina 1984; Karatygin & Azbukina 1989; Govorova 1990; Azbukina et al. 1995). The finding of *A. variabilis* in Russia was given as possible (Azbukina et al. 1995). The specimen of *A. variabilis* from the S. Kuriles (Kunashir), has also remained unnoticed by Russian mycologists. In the present work, *A. variabilis* is reported for the first time from the S. Kuriles, and it is a new species for Russia.

Carex cespitosa is removed from the list of hosts of *A. variabilis*.

Lit.: Ito (1935, 1936), Kakishima (1982), Katumoto (2010), Vánky (2011a).

On sect. *Stellulatae*

Anthracoidea karii (Liro) Nannf., Botaniska Notiser 130: 368, 1977. — *Cintractia karii* Liro, Mycotheca Fennica, no. 106, 1934. — Type on *Carex brunnescens*, Finland, Lapponia enontekiensis, Enontekiö, Vuontisjärvi, Peltovuoma, 24 Jul 1933, H. Roivainen & J.I. Liro; isotypes in Mycoth. fenn., no. 106. Figs 137–140

Sori in ovaries, scattered in the inflorescence, as subglobose to broadly ellipsoidal, black, hard bodies, 1.5–2 mm long, when young covered by a thin membrane; spore mass of the mature sori powdery on the surface. **Spores** flattened, in plane view suborbicular, broadly elliptical or slightly irregular in outline, in plane view $17\text{--}21.5 \times 14.5\text{--}20$ ($19.1 \pm 0.9 \times 17.0 \pm 1.2$) μm ($n/1 = 50$), in side view $10\text{--}12.5$ μm thick, middle reddish brown; wall more or less evenly thickened, $1.1\text{--}1.9$ μm thick, sometimes 1–2 internal swellings present, light-refractive areas and protuberances absent; in LM smooth to punctate, spore profile not affected; in SEM punctate to verruculose, warts up to 0.2 μm high, warts often confluent forming small groups or short rows. **Spore germination** of *Anthracoidea*-type (Nannfeldt 1977: 368; Vánky 2011a: 44).

Hosts — On *Cyperaceae*: *Carex* sect. *Stellulatae*: *Carex omiana* Franch. & Sav. var. *omiana*, *C. omiana* var. *monticola* Ohwi.

Distribution within the studied area — On *C. omiana* var. *omiana*, South Kuriles (Kunashir); on *C. omiana* var. *monticola*, Japan (Honshu).

Specimen examined.

On *Carex omiana* var. *monticola* Ohwi:

Japan: Honshu, Yamagata Pref., Mt. Chokaisan, 5th stage, 22 Jul 1927, leg. H. Ono (as *Cintractia* sp., TNS-F 207 658) (pl. rev.).

Literature records (specimens not seen).

On *Carex omiana* Franch. & Sav. var. *omiana*:

South Kuriles: Kunashir (Govorova 1990; Azbukina et al. 1995).

Known hosts — On *Cyperaceae*: on sedges from sect. *Canescentes*, sect. *Dispermae*, sect. *Physoglochin*, and sect. *Stellulatae*.

General distribution. Asia (China, Japan, Mongolia, Russia — West Siberia, Far East), Europe, North America, and Greenland.

Comments — *Anthracoidea karii* is known to infect 20 species of *Carex* which are mainly found in the Temperate and Subarctic regions of the Northern Hemisphere. Its principal host is *Carex echinata*.

The hosts of *A. karii* are members of four sections of *Carex*. There are different opinions about the taxonomic position of *C. sect. Physoglochin* (syn. *Dioicae*). According to Egorova (1999), it is a part of *C. subg. Psyllophora*. Other authors treat *C. sect. Physoglochin* as belonging to *C. subg. Vignea* (e.g. Chater 1980; Hendrichs et al. 2004), which is supported by molecular data (Hendrichs et al. 2004: 121). This section includes four sedges which are hosts of *A. karii*: *Carex davalliana*, *C. dioica*, *C. gynocrates*, and *C. parallela*; two of which, *C. dioica* and *C. parallela*, are common hosts of this smut fungus.

Anthracoidea karii is distributed in Europe, Asia, and North America.

Carex omiana has an Eastern Asiatic distribution. It includes three varieties. *Carex omiana* var. *omiana* occurs in the South Kuriles, Japan, and NE China. It is recorded as infected by *A. karii* only from Kunashir (Govorova 1990; Azbukina et al. 1995). *Carex omiana* var. *monticola* is endemic to Japan (Hokkaido and Honshu). On this host plant, *A. karii* is reported here for the first time from Japan, and as a new fungus-host combination.

On *Kobresia*

Anthracoidea elyinae (Syd.) Kukkonen, Annales Botanici Societatis Zoologicae Botanicae Fennicae 'Vanamo' 34(3): 65, 1963. — *Cintractia elyinae* Syd., Annales Mycologici 22: 289, 1924. — Lectotype on *Kobresia myosuroides* Switzerland, 'Horald bei Zermatt', 29 Aug 1886, P. Magnus (S) (design. by Kukkonen 1961: 157).

Literature records (specimens not seen).

On *Kobresia myosuroides* (Vill.) Fiori:

North Kuriles: Paramushir (Govorova 1990; Azbukina et al. 1995).

Excluded species

Anthracoidea obovoidea (Togashi & Y. Maki) Kakish., Memoirs of Institute of Agriculture and Forestry, University of Tsukuba 1: 28, 1982. — *Cintractia obovoidea* Togashi & Y. Maki, Annales of the Phytopathological Society of Japan 10: 139, 1940. — Holotype on *Carex fernaldiana*, Japan: Kyushu, Saga Pref., Karatsu, 22 May 1937, leg. Y. Maki (as on *Carex tenuissima* Boott, SAPA, sine num.!).

Sori in ovaries, scattered in the inflorescence. **Spores** variable in shape, globose, subglobose, broadly ellipsoidal or ellipsoidal, often irregular, $5.5\text{--}10 \times 4.5\text{--}9.5$ ($7.4 \pm 0.9 \times 6.1 \pm 0.9$) μm ($n/1 = 50$), greenish brown. **Spore germination** unknown.

Specimen examined.

On *Carex fernaldiana* H. Lév. & Vaniot:

Japan: Kyushu, Saga Pref., Karatsu, 22 May 1937, leg. Y. Maki (the host plant as *Carex tenuissima* Boott; SAPA – holotype) (pl. rev.).

Distribution: known from Japan.

Comments — There are no preserved sori in the herbarium packet of the type specimen. The present description is based on a study of a fragmentary spore mass retained inside the packet. The following observations were established: (i) small spore sizes, unusual for a species of *Anthracoidea*; ornamentation and spore sizes similar with those known for some *Farysia* species; (ii) presence of sterile hyphae between the spores; (iii) olive brown colour of the spores, unusual for a species of *Anthracoidea* but common for some *Farysia* species. Surely, this specimen belongs to a *Farysia* species. Vánky (2007) also concluded that this specimen represents a *Farysia* species.

Lit.: Togashi & Maki (1940), Kakishima (1982), Vánky (2007), Katumoto (2010).

Geographic ranges of the *Anthracoidea* species distributed in Japan and Korea

As it was observed by Nannfeldt (1979: 6), the maximum geographic range of a parasitic fungus is the range of its host (or the combined ranges of its hosts) but the fungus usually has a smaller range because the parasite has ecological demands of its own and because its dispersal may not be as effective as expected.

Assessment of geographic ranges depends on an accumulation of distribution records. The level of completeness of that information varies among regions. In the present case, it is a real problem because there are a limited number of records, especially for Siberia, Middle and Western Asia, Mongolia, China, and Eastern Asia.

The ranges of the *Anthracoidea* species are distinguished by us by comparing the whole range (or its main part) to the geographical areas defined by Takhtajan (1986). Fungi considered to have more or less continuous or disjunct ranges within cold or temperate belts of the northern hemisphere, within the limits of the Circumboreal Region in the sense of Takhtajan (1986), are called here circumboreal (as ‘circumpolar’ by Egorova 1999). One species is recognized here as temperate-Eurasiatic when its range is in the territory of temperate Eurasia mainly within the limits of the Circumboreal Region in the sense of Takhtajan (op.c.) (comp. Egorova 1999).

The assessment is based on existing collections and available literature records.

Anthracoidea blepharicarpae is endemic to Japan.

Anthracoidea buxbaumii is a circumboreal species.

Anthracoidea capillaris is a circumboreal species found on boreal-montane or montane host plants.

Anthracoidea caricis is a Eurasiatic species, which range is mainly in the territory of temperate Eurasia. Based on the present knowledge, this fungus has a disjunct distribution in Europe, Mongolia, and in East Asia. If we accept that the North American specimens, identified as *A. caricis*, do not belong to a distinct species, then *A. caricis* should be considered as a circumboreal species.

Anthracoidea caricis-grallatoriae is endemic to Japan (known only from the type locality).

Anthracoidea caryophylleae is a Holarctic-Australian species.

Anthracoidea dispalatae is endemic to Japan (known only from the type locality).

Anthracoidea globularis is a boreal, Eurasiatic species.

Anthracoidea humilis is a temperate-Eurasiatic species found on a temperate-Eurasiatic (*Carex humilis*) and two Eastern Asiatic (*C. lanceolata* and *C. rhizina* subsp. *reventa*) sedges. Based on the present knowledge, *A. humilis* has a disjunct distribution in Europe and in the Russian Far East and Japan.

Anthracoidea irregularis is a temperate-Eurasiatic species. Based on the present knowledge, it has a disjunct distribution in Europe and in Mongolia, China, Russian Far East, and Japan.

Anthracoidea japonica is endemic to Japan (known only from the type locality).

Anthracoidea kariii is a circumboreal species.

Anthracoidea lanceolatae is endemic to South Korea (known only from the type locality).

Anthracoidea limosa is a circumboreal species. Further studies must be carried out in order to establish whether the Eastern Asian and North American specimens belong to the same species or to distinct ones.

Anthracoidea michelii is a temperate-Eurasiatic species found on two Eurocaucasian (*Carex michelii* and *C. brevicollis*) and a Far Eastern (*C. longirostrata*) host plants. Based on the present knowledge, this fungus has a disjunct distribution from Central, SE and E Europe to Iran, and in the Russian Far East and Japan.

Anthracoidea microsora is endemic to Japan.

Anthracoidea pilosae is a temperate-Eurasiatic species. Similarly to its host plant, the fungus has a disjunct distribution in Europe (from Central Europe to East Europe and the Baltic States) and in East Asia (the Russian Far East and Japan). It is a case, in which the parasitic fungus follows the distribution of its host.

Anthracoidea sempervirentis is a temperate-Eurasiatic species, which range is mainly in Europe (from the Spanish Pyrenees to the Balkan Peninsula). Based on the present knowledge, this fungus has a disjunct distribution in Europe, Central China, and Japan.

Anthracoidea siderostictae is an Eastern Asiatic species.

Anthracoidea subinclusa has a Holarctic-Holantarctic range.

Anthracoidea variabilis is an Eastern Asiatic species.

Conclusions

The purpose of this investigation was to develop taxonomic knowledge of *Anthracoidea* in Japan and the adjacent regions. The study yielded description of three new smut fungi: *Anthracoidea caricis-grallatoriae* on *Carex grallatoria* from Japan, *Anthracoidea lanceolatae* on *Carex lanceolata* from South Korea, and *Anthracoidea pseudomichelii* on *Carex michelii* from Central Europe. Twenty *Anthracoidea* species are reported from Japan (*A. blepharicarpae*, *A. buxbaumii*, *A. capillaris*, *A. caricis*, *A. caricis-grallatoriae*, *A. caryophylleae*, *A. dispalatae*, *A. globularis*, *A. humilis*, *A. irregularis*, *A. japonica*, *A. kariii*, *A. limosa*, *A. michelii*, *A. microsora*,

A. pilosae, *A. sempervirentis*, *A. siderostictae*, *A. subinclusa*, and *A. variabilis*), and a total of 29 species from the study area (Table 14), as follows:

Sakhalin: *A. arnellii*, *A. caryophylleae*, *A. globularis*, *A. heterospora*, *A. misandrae*, *A. paniceae*, *Anthracoidea* sp. on *Carex blepharicarpa*; *Anthracoidea* sp. on *Carex longirostrata*;

North Kuriles: *A. atratae*, *A. capillaris*, *A. caricis*, *A. elynae*, *A. limosa*, *A. liroi*, *A. paniceae*, *A. subinclusa*;

South Kuriles: *A. buxbaumii*, *A. capillaris*, *A. caryophylleae*, *A. kariii*, *A. laxae*, *A. limosa*, *A. variabilis*, *Anthracoidea* sp. on *Carex blepharicarpa*;

Hokkaido: *A. blepharicarpae*, *A. buxbaumii*, *A. caricis*, *A. caryophylleae*, *A. limosa*, *A. pilosae*, *A. siderostictae*, *A. subinclusa*, *Anthracoidea* sp. on *Carex conica*;

Rishiri: *Anthracoidea* sp. on *Carex blepharicarpa*;

Honshu: *A. capillaris*, *A. caricis-grallatoriae*, *A. caryophylleae*, *A. dispalatae*, *A. humilis*, *A. irregularis*, *A. kariii*, *A. michelii*, *A. microsora*, *A. siderostictae*, *A. variabilis*, *Anthracoidea* sp. on *Carex foliosissima*, *Anthracoidea* sp. on *Carex alterniflora* var. *fulva*, *Anthracoidea* sp. on *Carex conica*, *Anthracoidea* sp. on *Carex dolichostachya* var. *glaberrima*, *Anthracoidea* sp. on *Carex morrowii*;

Shikoku: *A. japonica*, *A. microsora*, *A. sempervirentis*, *A. siderostictae*, *Anthracoidea* sp. on *Carex mitrata*; *Anthracoidea* sp. on *Carex morrowii*;

Kyushu: *Anthracoidea microsora*;

Unknown distribution in Japan: *Anthracoidea globularis*;

South Korea: *A. caryophylleae*, *A. lanceolatae*, *A. siderostictae*, *Anthracoidea* sp. on *Carex longirostrata*.

Table 14. List of the established *Anthracoidea* species within the study area and their distribution on the islands

Species	Sakhalin	North Kuriles	South Kuriles	Hokkaido	Honshu	Shikoku	Kyushu	Japan – without a locality	South Korea
1 <i>Anthracoidea arnellii</i>	+								
2 <i>Anthracoidea atratae</i>		+							
3 <i>Anthracoidea blepharicarpae</i>				+					
4 <i>Anthracoidea buxbaumii</i>			+	+					
5 <i>Anthracoidea capillaris</i>		+	+		+				
6 <i>Anthracoidea caricis</i>		+		+					
7 <i>Anthracoidea caricis-grallatoriae</i>					+				
8 <i>Anthracoidea caryophylleae</i>	+		+	+	+				+
9 <i>Anthracoidea dispalatae</i>					+				
10 <i>Anthracoidea elynae</i>		+							
11 <i>Anthracoidea globularis</i>	+							+	
12 <i>Anthracoidea heterospora</i>	+								
13 <i>Anthracoidea humilis</i>					+				
14 <i>Anthracoidea irregularis</i>					+				
15 <i>Anthracoidea japonica</i>						+			
16 <i>Anthracoidea kariii</i>			+		+				
17 <i>Anthracoidea lanceolatae</i>									+
18 <i>Anthracoidea laxae</i>			+						
19 <i>Anthracoidea limosa</i>		+	+	+					
20 <i>Anthracoidea liroi</i>		+							
21 <i>Anthracoidea michelii</i>					+				
22 <i>Anthracoidea microsora</i>					+	+	+		
23 <i>Anthracoidea misandrae</i>	+								
24 <i>Anthracoidea paniceae</i>	+	+							
25 <i>Anthracoidea pilosae</i>				+					
26 <i>Anthracoidea sempervirentis</i>						+			
27 <i>Anthracoidea siderostictae</i>				+	+	+			+
28 <i>Anthracoidea subinclusa</i>		+		+					
29 <i>Anthracoidea variabilis</i>			+		+				
Total	6	8	7	8	11	4	1	1	3

In the study area, forty-seven species of *Carex* and one of *Kobresia* were found to be infected by species of *Anthracoidea* (Table 15).

Table 15. List of host species with their respective smut fungi

Host plant	Smut fungus
<i>Carex alterniflora</i> var. <i>alterniflora</i>	<i>Anthracoidea microsora</i>
<i>Carex alterniflora</i> var. <i>fulva</i>	<i>Anthracoidea</i> sp.
<i>Carex arenicola</i>	<i>Anthracoidea variabilis</i>
<i>Carex arnellii</i>	<i>Anthracoidea arnellii</i>
<i>Carex blepharicarpa</i>	<i>Anthracoidea blepharicarpae</i>
<i>Carex buxbaumii</i>	<i>Anthracoidea buxbaumii</i>
<i>Carex capillaris</i>	<i>Anthracoidea capillaris</i>
<i>Carex cespitosa</i>	<i>Anthracoidea heterospora</i>
<i>Carex ciliatomarginata</i>	<i>Anthracoidea siderostictae</i>
<i>Carex conica</i>	<i>Anthracoidea</i> sp.
<i>Carex dispalata</i>	<i>Anthracoidea dispalatae</i>
<i>Carex dolichostachya</i> var. <i>glaberrima</i>	<i>Anthracoidea</i> sp.
<i>Carex duvaliana</i>	<i>Anthracoidea microsora</i>
<i>Carex fernaldiana</i>	<i>Anthracoidea microsora</i>
<i>Carex flavocuspis</i> subsp. <i>krascheninnikovii</i>	<i>Anthracoidea atratae</i>
<i>Carex foliosissima</i>	<i>Anthracoidea caryophylleae</i>
<i>Carex globularis</i>	<i>Anthracoidea globularis</i>
<i>Carex gmelinii</i>	<i>Anthracoidea buxbaumii</i>
<i>Carex grallatoria</i>	<i>Anthracoidea japonica</i> <i>Anthracoidea caricis-grallatoriae</i>
<i>Carex lanceolata</i>	<i>Anthracoidea humilis</i> <i>Anthracoidea irregularis</i> <i>Anthracoidea lanceolatae</i>
<i>Carex laxa</i>	<i>Anthracoidea laxae</i>
<i>Carex leucochlora</i>	<i>Anthracoidea caryophylleae</i>
<i>Carex limosa</i>	<i>Anthracoidea limosa</i>
<i>Carex livida</i>	<i>Anthracoidea paniceae</i>
<i>Carex longirostrata</i>	<i>Anthracoidea michelii</i>

Table 15. (continued)

Host plant	Smut fungus
	<i>Anthracoidea</i> spp.
<i>Carex makinoensis</i>	<i>Anthracoidea sempervirentis</i>
<i>Carex microtricha</i>	<i>Anthracoidea caryophylleae</i>
<i>Carex middendorffii</i>	<i>Anthracoidea liroi</i>
<i>Carex mitrata</i> var. <i>aristata</i>	<i>Anthracoidea caryophylleae</i>
<i>Carex mitrata</i> s. lat.	<i>Anthracoidea</i> sp.
<i>Carex miyabei</i>	<i>Anthracoidea subinclusa</i>
<i>Carex morrowii</i>	<i>Anthracoidea caryophylleae</i>
<i>Carex nervata</i>	<i>Anthracoidea caryophylleae</i>
<i>Carex nesophila</i>	<i>Anthracoidea atratae</i>
<i>Carex omiana</i> var. <i>monticola</i>	<i>Anthracoidea kariii</i>
<i>Carex omiana</i> var. <i>omiana</i>	<i>Anthracoidea kariii</i>
<i>Carex oxyandra</i>	<i>Anthracoidea caricis</i>
<i>Carex pilosa</i>	<i>Anthracoidea pilosae</i>
<i>Carex pisiformis</i> var. <i>pisiformis</i>	<i>Anthracoidea</i> sp.
<i>Carex podocarpa</i>	<i>Anthracoidea atratae</i>
<i>Carex rariflora</i>	<i>Anthracoidea limosa</i>
<i>Carex saxatilis</i>	<i>Anthracoidea subinclusa</i>
<i>Carex siderosticta</i>	<i>Anthracoidea siderostictae</i>
<i>Carex stenantha</i> var. <i>taisetsuensis</i>	<i>Anthracoidea misandrae</i>
<i>Carex stenostachys</i> var. <i>cuneata</i>	<i>Anthracoidea microsora</i>
<i>Carex subebracteata</i>	<i>Anthracoidea caryophylleae</i>
<i>Carex tenuiformis</i>	<i>Anthracoidea capillaris</i>
<i>Carex tenuinervis</i>	<i>Anthracoidea microsora</i>
<i>Carex vaginata</i> var. <i>petersii</i>	<i>Anthracoidea paniceae</i>
<i>Carex vaginata</i> var. <i>vaginata</i>	<i>Anthracoidea paniceae</i>
<i>Carex vanheurckii</i>	<i>Anthracoidea caricis</i>
 <i>Kobresia myosuroides</i>	 <i>Anthracoidea elynae</i>

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Fig. 3. Sori – habit: **a** – *A. globularis* on *Carex globularis* (Sakhalin Island, 24 Jul 1906, K. Miyabe & T. Miyagi, SAPA, sine num.), **b** – *A. dispalatae* on *Carex dispalata* (TSH, sine num., holotype), **c** – *A. pilosae* on *Carex pilosa* (Ishikari Prov., Garugawa, 9 Jul 1891, K. Miyabe, SAPA, sine num.), **d** – *A. humilis* on *Carex lanceolata* (Tochigi Pref., Iwafune-yama, 14 May 1950, K. Okamoto, TNS-F, sine num.), **e** – *A. irregularis* on *Carex lanceolata* (Prov. Rikuzen, Sendai, 4 Jun 1905, A. Yasuda, SAPA, sine num.), **f** – *A. lanceolatae* on *Carex lanceolata* (SOMF 28 090, holotype). Scale bars = 0.5 cm

Fig. 4. Sori – habit: g – *A. japonica* on *Carex grallatoria* (SAPA, sine num., holotype), h – *A. blepharicarpae* on *C. blepharicarpa* (SAPA, sine num., holotype), i – *A. caryophylleae* on *Carex microtricha* (Kurile Islands, Etorofu, 19 Jul 1906, K. Miura, SAPA, sine num.), j – *A. siderostictae* on *Carex siderosticta* (TNS-F 229 992), k – *A. variabilis* on *Carex arenicola* (SAPA, sine num., holotype), l – *A. kariii* on *Carex omiana* var. *monticola* (TNS-F 207 658). Scale bars = 0.5 cm

Figs 5–8. *Anthracoidea caricis* on *Carex oxyandra* (TSH, sine num., 21 Aug 1926). Spores viewed with LM and SEM. Scale bars: 5, 6 = 10 μm ; 7, 8 = 5 μm

Figs 9–12. *Anthracoidea caricis* on *Carex pilulifera* (TUR, neotype). Spores viewed with LM and SEM. Scale bars: 9, 10 = 10 µm; 11, 12 = 5 µm

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Figs 49–52. *Anthracoidea pilosae* on *Carex pilosa* (H.U.V. 134, holotype). Spores viewed with LM and SEM. Scale bars: 49, 50 = 10 μ m; 51, 52 = 5 μ m

Figs 53–56. *Anthracoidea humilis* on *Carex lanceolata* (TSH, sine num., 1 May 1961). Spores viewed with LM and SEM. Scale bars: 53, 54 = 10 μ m; 55, 56 = 5 μ m

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Figs 69–72. *Anthracoidea lanceolatae* on *Carex lanceolata* (SOMF 28 090, holotype). Spores viewed with SEM. Scale bars = 5 μ m

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