Appendix

Keys to the Genera/Species of the Kickxellales *sensu lato*

INTRODUCTION

Up to the present, several keys to the genera of the Kickxellales *sensu lato* (*s. l.*) have been provided based on the asexual reproductive morphology (Linder 1943, Benjamin 1963, Zycha et al. 1969). Their keys are largely accommodative, however, some of the features employed in the keys are undoubtedly inappropriate. For instance, Benjamin (1963) and Zycha et al. (1969) confused the terms indicating the arrangement/distribution of sporocladia on sporangiophore ('verticillate' or 'umbellate') and the terms describing the ontogeny of sporocladia ('acrogenous' or 'pleurogenous') in an article in their dichotomous keys. In addition, Zycha et al. (1969) employed the feature of 'coiling sporangiophores' in an inappropriate article in their key.

In spite of these conflicts, no attempts have been done to amend the keys. Because the present study added several new taxa to the order, the keys should be brought up to date. Thus, in this appendix, comprehensive and more consistent keys that cover all the known genera/species of the Kickxellales *s. l.* will be proposed.

In the following part, keys to (1) the genera of the Kickxellales *s. l.*, (2) the species of the Spiromycetales (tentative name), and (3) the species of the Ramicandelaberales (tentative name) will be presented. The keys are mainly based on the asexual reproductive morphology at the optical microscopic level so that researchers who are not acquainted with this group of fungi can easily identify them only by optical microscopic observations. For preparations of these keys, Benjamin (1958, 1963), Zycha et al. (1969), O'Donnell (1979), and Young (1999) were referred in addition to the descriptions of each genus (Coemans 1862, 1863; van Tieghem & Le Monnier 1873; Raper & Fennell 1952; Meyer 1957; Benjamin 1959, 1961, 1963; Ogawa et al. 2001; Kurihara et al. 2001).

DESCRIPTION OF THE KEYS

(1) Key to the genera of the order Kickxellales *sensu lato*

Key to genera of Kickxellales *sensu lato*

1 Sporocladia bearing spores on pedicels or directly on sporocladia; pseudophialides not produced; zygospores punctulate where known.....2 (Spiromycetales, tentative name)
Sporocladia bearing spores on pseudophialides; zygospores smooth where known.....3

2 Sporocladia globose with a stalk or sicyoid, produced pleurogenously in solitary; spores globose, formed on a short pedicel on sporocladia, remain dry at maturity.....**Spiromyces**
Sporocladia lageniform with long necks, produced acrogenously in mass or pleurogenously in solitary; spores fusiform, formed directly on sporocladia, immersed in liquid at maturity.....**Mycoemilia** (tentative name)

3(1) Sporocladium usually composed of a single cell.....4
Sporocladium composed of several cells.....6

4(3) Only a single pseudophialide formed on a sporocladial cell before senescence.....**Ramicandelaber** (Ramicandelaberales, tentative name)
Several to many pseudophialides formed on a sporocladial cell.....5

5(4) Sporocladium single, large, and lenticular; sporangiophore septal plugs lacking protuberances.....**Linderina**
Sporocladia cylindrical, one- or sometimes two-celled, many on a sporangiophore vesicle; sporangiophore septal plugs bearing protuberances.....**Myconymphaea**

6(3) Sporangiola ovoid, the ratio of length to width does not exceed 2; sporangiospores dry at maturity.....**Spirodactylon**
Sporangiola elongate, the ratio of length to width exceeds 2; sporangiospores wet at maturity.....7

7(6) Sporocladia produced from a vesicle, arranged in verticillate or umbellate.....8
Sporocladia not produced from a vesicle, arranged in racemose or scorpioid.....9

8(7) Sporocladia without a stalk, arranged in verticillate; apical cell of sporocladium often furcate; sporangiola and sporangiospores fusiform.....**Kickxella**
Sporocladia with a stalk, arranged in umbellate; apical cell of sporocladium simple; sporangiola alate; sporangiospores obclavate.....**Martensiomyces**

9(7) Sporocladia produced pleurogenously; sporangiola acuminate.....**Dipsacomyces**
Sporocladia produced acrogenously; sporangiola fusiform or aciculate...10

10(9) Pseudophialides formed on the upper surface of the sporocladium.....**Martensella**
Pseudophialides formed on the lower surface of the sporocladium..**Coemansia**

(2) Key to the species of the order Spiromycetales (tentative name) and the family Spiromycetaceae (tentative name)

Key to the species of the order Spiromycetales (tentative name) (= Key to the species of the family Spiromycetaceae, tentative name)

1 Sporocladia globose with a stalk or sicyoid, produced pleurogenously in solitary; spores globose, formed on a short pedicel on sporocladia, remain dry at maturity.....2 (Spiromyces)
Sporocladia lageniform with long necks, produced acrogenously in mass or pleurogenously in solitary; spores fusiform, formed directly on sporocladia, immersed in liquid at maturity.....**Mycoemilia scoparia** (tentative name)

2(1) Sporophores coiled, sporocladia sicyoid, spores ovoid, spinose.....**Spiromyces minutus**
Sporophores not coiled, sporocladia globose with a globose stalk, spores subglobose, warted.....**S. aspiralis**

Note: *Spiromyces* sp. of Mikawa (1975) is not taken into this key, because the species has not been described validly.

(3) Key to the species of the order Ramicandelaberales (tentative name) and the family Ramicandelaberaceae (tentative name)

Key to the species of the Ramicandelaberales (tentative name) (= Key to the species of the Ramicandelaberaceae, tentative name = Key to the species of the Ramicandelaber)

1 Spores (33-) 40-44 (-55) × (3-) 5-6 (-9) μm, no. of fertile branches per globose body 1-4, fertile branches (8-) 11-13 (-15) × 1.5-3.5 μm, lateral branches absent.....Ramicandelaber longisporus

Spores 17.5-25.0 (21.0±0.2) × 3.0-4.0 (3.8±0.0) μm, no. of fertile branches per globose body 3-13 (8), fertile branches 15.0-34.0 (25.8±0.4) × 2.5-4.5 (3.5 ± 0.1) μm, lateral branches usually present.....R. brevisporus (tentative name)

ACKNOWLEDGEMENTS

I wish to express my gratitude to Prof. T. Hori, University of Tsukuba for his patience throughout this work. I cordially thank Prof. I. Inouye, University of Tsukuba for his criticism and advice on this work. I am sincerely obliged to Dr. S. Tokumasu, Sugadaira Montane Research Center, University of Tsukuba for his continuous encouragement and support during my work.

I also thank Dr. Y. Suyama, Tohoku University, Drs T. Mikawa and M. Sugiyama, Mitsubishi Chemical Corporation, and Dr. D. Honda, Konan University for teaching me molecular analysis techniques.

I sincerely appreciate to Dr. Y. Ogawa, Nihon University and Dr. H. Sato, Forestry and Forest Products Research Institute for allowing me to read their manuscripts before publication. I am grateful to Prof. C.-Y. Chien, Taiwan National Normal University for his helpful suggestions and encouragements. I would like to thank Dr. W. Gams, Centraalbureau voor Schimmelcultures for providing CBS cultures for me.

This dissertation would not be done without the kind assistance of the members of the Sugadaira Montane Research Center of University of Tsukuba; Prof. I. Hayashi, Dr. R. Machida, Dr. K. Yahata, Dr. Y. Degawa (present address: Kanagawa Prefectural Museum), Dr. Y. Ikeda (present address: Oita Medical University), and Dr. K. Tojo (present address: Institute of Insect and Animal Sciences). I also wish to express my sincere appreciation to all other members of the center, especially Drs S. Inaba and S. Iwamoto (present addresses: BRC) and Mr. O. Matsuzawa for their technical support to my work.

I wish to express my gratitude to Dr. N. Kotaka, University of Hokkaido (present address: Osaka City University) for providing me samples and Dr. Y. Doi, National Museum of Natural Science for his advice.

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Table 1-1. The classification system of the phylum Zygomycota based on Kirk et al. (2001) except for the data on the Kickxellales.

Phylum Zygomycota: 2 classes, 15 orders, 38 families, 181 genera, 1090 species

Class Zygomycetes: 10 orders, 32 families, 124 genera, 870 species

- Order Kickxellales: 1 family, 10 genera, 28 species
- Order Dimargaritales: 1 family, 4 genera, 14 species
- Order Mucorales: 12 families, 47 genera, 130 species
- Order Zoopagales: 5 families, 21 genera, 163 species
- Order Entomophthorales: 6 families, 22 genera, 182 species
- Order Endogonales: 1 family, 4 genera, 27 species
- Order Mortierellales: 1 family, 7 genera, 106 species
- Order Basidiobolales: 1 family, 1 genus, 4 species
- Order Glomerales*: 3 families, 6 genera, 157 species
- Order Geosiphonales*: 1 family, 1 genus, 1 species

Class Trichomycetes: 3 orders, 6 families, 55 genera, 218 species

- Order Harpellales: 2 families, 33 genera, 142 species
- Order Asellariales: 1 family, 3 genera, 11 species
- Order Eccrinales: 3 families, 18 genera, 62 species

*: Quite recently, these orders were removed from the phylum Zygomycota and compiled into a new phylum Glomeromycota Schüßler et al. 2001 (Schüßler et al. 2001).

Table 1-2. A complete list of the species of the Kickxellales as of 2002.

Order Kickxellales Kreisel ex R. K. Benj. 1979
Family Kickxellaceae Linder 1943

1. *Coemansia aciculifera* Linder 1943
   1'. *Coemansia aciculifera* var. *suhagensis* B. R. Mehrotra et Kakkar 1970
2. *Coemansia braziliensis* Thaxter ex Linder 1943
3. *Comansia breviramosa* Linder 1943
4. *Comansia ceylonensis* Linder 1943
5. *Comansia erecta* Bainier 1906
6. *Comansia furcata* Kurihara, Tokumasu et C.-Y. Chien 2000
7. *Comansia guatemalensis* Thaxter ex Linder 1943
8. *Comansia interrupta* Linder 1943
9. *Comansia kamerunensis* Thaxter ex Linder 1943
10. *Comansia mojavensis* R. K. Benj. 1958
11. *Comansia nanatahalensis* C.-Y. Chien 1971
12. *Comansia pectinata* Bainier 1906
13. *Comansia reversa* van Tiegh. et G. Le Monn. 1873
14. *Comansia scorpioidea* Linder 1943
15. *Comansia spiralis* Eidam 1887
16. *Comansia thaxteri* Linder 1943
17. *Dipsacomyces acuminosporus* R. K. Benj. 1961
18. *Kickxella alabastrina* Coemans 1862
19. *Linderina macrospora* Chang 1967
20. *Linderina pennispora* Raper et Fennell 1952
21. *Martensella corticii* Thaxter ex Linder 1943
22. *Martensella pectinata* Coemans 1863
23. *Martensiomyces pterosporus* Meyer 1957
24. *Myconymphaea yatsukahoi* Kurihara, Degawa et Tokumasu 2001
25. *Ramicandelaber longisporus* Ogawa, Hayashi, Degawa et Yaguchi 2001
26. *Spirodactylon aureum* R. K. Benj. 1959
27. *Spiromyces aspiralis* Benny et R. K. Benj. 1998
28. *Spiromyces minutus* R. K. Benj. 1963

Table 2-1. Known localities and presumptive distributions of the genera of the Kickxellales.

genus	known localities[*1]	presumptive distribution (Kirk 1993)	occurrence in Japan	rareness of the genus[*2]
Coemansia	Europe, West Africa North and Central America, East and South Asia	widespread	recorded	S
Kickxella	Europe, North America, Japan	temperate	recorded	–
Martensella	Europe, North America	temperate	not recorded	S
Dipsacomyces	Honduras	tropics	not recorded	G
Martensiomyces	Congo	tropics	not recorded	G
Linderina	Africa, India, Hong Kong, Malaysia, USA	tropics	not recorded	–
Spirodactylon	USA (desert)	tropics	not recorded	G
Spiromyces	USA (desert), Japan, Pakistan	tropics	recorded	S
Ramicandelaber	–	–	recorded	–
Myconymphaea	–	–	recorded	G
Mycoemilia	–	–	recorded	G

[*1]: Mainly based on Young (1999); CBS list of cultures (http://www.cbs.knaw.nl/search_fsp.html) and Saikawa (1989) were used additionally.

[*2]: G: Genera that include a species that has never been recorded after its original description. S: Monotypic genera of which type species have never been reported since original descriptions.

Table 2-2. Known sources of the isolates of the Kickxellales.

species	sources							total
	compound substrata*1		ordinal substrata					
	feces	soil	roots	plant debris	fungi	mam-mals*2	in-sects	
Coemansia aciculifera	0	7	5	2	0	0	0	14
C. aciculifera var.*suhagensis*	0	1	0	0	0	0	0	1
C. braziliensis	0	0	0	1(?)	0	0	0	1(?)
C. breviramosa	2	0	0	0	0	0	0	2
C. ceylonensis	0	0	0	1	0	0	0	1
C. erecta	3	3	0	3	0	0	1	10
C. guatemalensis	2	0	0	0	0	0	0	2
C. interrupta	2	0	0	0	0	0	0	2
C. kamerunensis	1	0	0	0	0	0	0	1
C. mojavensis	1	0	0	0	0	0	0	1
C. nanatahalensis	0	1	0	0	0	0	0	1
C. pectinata	1	0	0	0	0	0	0	1
C. reversa	0	0	0	0	6	0	0	6
C. scorpioidea	1	0	1	0	0	0	0	2
C. spiralis	0	0	0	0	0	1	0	1
C. thaxteri	0	0	1	0	0	0	1	2
Dipsacomyces acuminosporus	0	1	0	0	0	0	0	1
Kickxella alabastrina	5	0	0	0	0	0	0	5
Linderina macrospora	0	2	0	0	0	0	0	2
L. pennispora	0	1	0	0	0	0	0	1
Martensella corticii	0	0	0	0	2	0	0	2
M. pectinata	0	0	0	0	1	0	0	1
Martensiomyces pterosporus	0	1	0	0	0	0	0	1
Ramicandelaber longisporus	0	1	0	0	0	0	0	1
Spirodactylon aureum	5	0	0	0	0	0	0	5
Spiromyces aspiralis	1	0	0	0	0	0	0	1
S. minutus	1	0	0	0	0	0	0	1
Spiromyces sp.*3	1	0	0	0	0	0	0	1
total of the isolates	26	18	7	7	9	1	2	70

*1: Compound substrata that consist of many material including the real substrate of the isolate of the Kickxellales.

*2: A carcass of horse (Thaxter in Linder 1943).

*3: An undescribed species of the *Spiromyces* recorded by Mikawa (1975).

Table 2-3. Known fecal sources of the kickxellalean isolates.

species	sources										total
	mammals							avis	am-phib-ians	un-known	
	mouse	rat	horse	pig	zebra[*1]	deer	bat	duck	frog		
Coemansia breviramosa	2	0	0	0	0	0	0	0	0	0	2
C. erecta	1	0	0	0	0	0	1	0	0	1	3
C. guatemalensis	0	0	0	2	0	0	0	0	0	0	2
C. interrupta	0	0	0	0	0	0	0	0	1	1	2
C. kamerunensis	0	0	0	0	0	0	0	0	0	1	1
C. mojavensis	0	1	0	0	0	0	0	0	0	0	1
C. pectinata	0	0	1	0	0	0	0	0	0	0	1
C. scorpioidea	0	0	0	0	0	0	0	1	0	0	1
Kickxella alabastrina	1	0	2	0	1	1	0	0	0	0	5
Spirodactylon aureum	3	1	0	0	0	0	0	0	0	1	5
Spiromyces aspiralis	1	0	0	0	0	0	0	0	0	0	1
S. minutus	1	0	0	0	0	0	0	0	0	0	1
Spiromyces sp.[*2]	0	1	0	0	0	0	0	0	0	0	1
total of the isolates	9	3	3	2	1	1	1	1	1	4	26

[*1]: Under breeding in Paris, France (Torrey 1921).

[*2]: An undescribed species of the *Spiromyces* recorded by Mikawa (1975).

Table 2-4. Localities of soil samples examined in this study

locality[*1]	No. of samples	locality	No. of samples
Hokkaido	17	Mie	3
Aomori	15	Shiga	7
Iwate	23	Kyoto	11
Miyagi	16	Nara	6
Fukushima	1	Wakayama	20
Ibaraki	39	Okayama	2
Tochigi	1	Tottori	3
Gunma	31	Hiroshima	12
Saitama	74	Yamaguchi[*3]	43
Chiba	2	Kagawa	15
Tokyo[*2]	50	Tokushima	7
Kanagawa	23	Ehime	16
Yamanashi	18	Kouchi	43
Nagano	231	Kumamoto	7
Niigata	5	Miyazaki	39
Fukui	1	Kagoshima[*4]	18
Shizuoka	71	Okinawa[*5]	129
Aichi	13	total	1012

(to be continued to the next column)

*1: Localities are shown at the prefectural level.

*2: Samples from the Izu Islands and the Ogasawara Islands are included.

*3: Samples from the Yashiro (Suou-Ohshima) Island are included.

*4: Samples from the Yaku and the Amami Islands are included.

*5: Consists of the samples from the Okinawa, Ishigaki, Taketomi, Iriomote, and Yonaguni Islands.

Table 2-5. A list of fecal samples examined in the present study.

animals	No. of species*1	No. of samples*2	treatment*3
Mammals	16 with 1 unknown	96	mc/di
Amphibians	3	3	mc
Reptiles	2	2	mc
Arthropods	2 with 1 unknown	4	mc/di
Avis	1	1	mc
total	24 with 2 unknowns	106	—

*1: The number of animal species that provided the fecal samples.

*2: Each sample consisted of 1-50 fecal pellets.

*3: mc: Moist chamber method using *Sphagnum* material as a moisturizer. di: Direct inoculation method.

Table 2-6. A precise list of the fecal samples I. Mammals[*1].

providers of the feces	No. of samples[*2]	localities	treat-ment[*3]
Murines[*4] (Field mice and voles)	52	Nagano (51), Ibaraki (1)	mc/di
Japanese hare (*Lepus brachyurus*)	10	Nagano (7), Aomori (1), Gunma (1)	mc
Japanese serrow (*Capricornis crispus*)	7	Nagano (7)	mc
Bats	5	Iwate, Fukushima, Yamaguchi, Kouchi, Okinawa (Ishigaki Isl.)	mc
Sika deer (*Cervus nippon*)	4	Hiroshima (2), Kanagawa (1), Tokyo (Niijima Isl.) (1)	mc/di
Raccoon dog (*Nyctereutes procyonoides*)	5	Nagano (4), Gunma (1)	mc
Japanese macaque (*Macaca fuscata*)	2	Fukushima (1), Nagano (1)	mc
Amami rabbit (*Pentalagus furnessi*)	2	Kagoshima (Amami Isl.) (2)	di
Japanese squirrel (*Sciurus lis*)	1	Nagano (1)	mc
Wild boar (*Sus scrofa*)	1	Nagano (1)	mc
Goat (*Capra hircus*)	1	Gunma (under breeding, outdoor) (1)	mc
Dog (*Canis familiaris*)	1	Kanagawa (1)	di
Dzungarian hamster (*Phodopus sungorus*)	1	Nagano (under breeding, indoor) (1)	mc
African pigmy hedgehog (*Atelerix albiventris*)	1	Nagano (under breeding, indoor) (1)	mc
Yellow weasel (*Mustela itatsi*)	1	Tokyo (Hachijo Isl.) (1)	mc
Japanese black bear (*Ursus thibetanus*)	1	Nagano (1)	mc
unknown	1	Nagano (1)	mc

*1: The classification of mammals followed Abe et al. (1994).

*2: Each sample consisted of 1-50 fecal pellets.

*3: mc: Moist chamber method. di: Direct inoculation method.

*4: Almost all murine feces were collected at the Sugadaira Highland, Nagano Prefecture. Taking the habitats of murines into account, the feces collected at a grassland may be feces of *Microtus montebelli*, and those collected in forests may be those of *Apodemus speciosus* and/or *A. argenteus* (Kanamori & Ando 1974).

Table 2-7. A precise lists of the fecal samples Ⅱ.
Amphibians, Reptiles, Avis, and Arthropods.

Amphibians

amphibian species	No. of samples*1	localities	treat-ment*2
Blacked salamander (*Hynobius nigrescens*)	1	under breeding, captured in Nagano	di
Japanese clawed salamander (*Onychodactylus japonicus*)	1	Nagano	di
Eastern-Japanese common toad (*Bufo japonicus formosus*)	1	Nagano	mc

Reptiles

reptilian species	No. of samples*1	localities	treat-ment*2
House gecko (*Gekko japonicus*)	1	under breeding, captured in Okinawa (Okinawa Isl.)	mc
A species of lizards (*Japalura polygonata polygonata*)	1	under breeding, captured in Okinawa (Okinawa Isl.)	mc

Avis

avian species	No. of samples*1	locality	treat-ment*2
Japanese pheasant (*Phasianus versicolar*)	1	Nagano	mc

Arthropods

arthropod species	No. of samples*1	localities	treat-ment*2
A species of dragonflies (*Matrona basilaris japonica*)	1	Okinawa (Okinawa Isl.)	di
A species of terrestrial crabs (*Gecarcoidea lalandii*)	1	Okinawa (Taketomi Isl.)	di
unknown arthropod	2	Gunma	mc

*1: Each sample consisted of 1-50 fecal pellets.

*2: mc: Moist chamber method. di: Direct inoculation method.

Table 2-8. Kickxellalean species found in the present study I.

species found in the present study	criteria				
	un-described genus	un-described species	re-discovered species*2	species new to Japan*3	cultivated species
Coemansia aciculifera	−	−	−	−	+
C. erecta	−	−	−	−	+
C. furcata	−	+	−	+	+
C. mojabensis	−	−	+	+	+
C. nantahalensis	−	−	+	+	+
C. spiralis	−	−	−	+	+
C. sp. 1	−	+	−	+	+
Kickxella arabastrina	−	−	−	−	+
Mycoemilia scoparia *1	+	+	−	+	+
Myconymphaea yatsukahoi	+	+	−	+	+
Ramicandelabar brevisporus *1	−	+	−	+	+
R. longisporus	−	−	+	−	−
Spiromyces minutus	−	−	−	−	−
Kickxellaceae sp. 1	+	+	−	+	−
Kickxellaceae sp. 2	+	+	−	+	−

*1: Tentative names of undescribed species.

*2: Secondary recorded species after the original description.

*3: Species that have never been recorded in Japan.

Table 2-9. Kickxellalean species found in the present study II[*1].

criterion	No. of taxa/isolates
Species observed	15 species of 8 genera
Species cultivable[*2]	10 species of 4 genera
No. of cultures	268 cultures
Undescribed genera	2 genera
Undescribed species	5 species of 4 genera
Rediscovered species[*3]	3 species of 2 genera
Species new to Japan[*4]	3 species of 1 genus

[*1]: Twenty-eight species of 10 genera are known in the Kickxellales . This includes the 1 genus and the 2 species described as results of the present study.

[*2]: All species observed were tried to be isolated to establish axenic cultures. The 'species cultivable' are the species of which culture(s) could be established among them.

[*3]: Secondary recorded species after the original description.

[*4]: Species that have never been recorded in Japan.

Table 2-10. Comparative synopsis of *Coemansia furcata* and *Coemansia aciculifera* var. *suhagensis*.

characteristics*	*C. furcata* (type strain) on 1/2 ME-YE agar (Kurihara et al. 2000)	*C. aciculifera* var. *suhagensis* (type strain) on Oatmeal agar (Mehrotra & Kakkar 1970)
colonies	pale yellow	bright yellow
branching pattern of sporangiophores	unbranched or furcate below, furcate in the fertile part	unbranched below, branched in the fertile part
No. of cells of the stipe of sporocladia	1	1-3
length of the stipe (μm)	10.5-28.0 (16.3±0.4)	12.2-25 av. 22
width of the stipe (μm)	4.0-7.5 (5.4±0.1)	3.3-6.6 av. 5.5
No. of cells composing a sporocladium	7-13 (9±0.1)	4-9 av. 7
length of sporocladia (μm)	31.0-56.0 (39.4±0.4)	16.5-39.6 av. 25.3
width of sporocladia (μm)	5.5-7.5 (6.2±0.0)	3.3-5.5 av. 4.4
shape of the apical cell of sporocladia	tapering, beak-like, recurved	tapering, beak-like, recurved
shape of pseudophialides	flask-shaped	ovoid
length of pseudophialides (μm)	4.5-6.5 (5.5±0.0)	3.3-5.5 av. 4.4
width of pseudophialides (μm)	1.5-2.5 (2.0±0.0)	1.75-2.2 av. 2.2
shape of sporangiola	cylindrical, slightly arcuate, slightly pointed at the apex	acicular, tapering to both ends
length of sporangiola (μm)	10.0-17.5 (13.8±0.1)	13.2-16.5 av. 14.3
width of sporangiola (μm)	2.5-3.0 (2.7±0.0)	1.1-1.75 av. 1.75

*: Differential characteristics are emphasized with shade.

Table 2-11. Comparative synopsis of *Coemansia* sp. 1 and *C. mojavensis*.

characteristics*	*C.* sp. 1 on 1/2 ME-YE agar	*C. mojavensis* (type strain) on PAB-DEX (Benjamin 1958)
colonies	somewhat sulphur-yellow	pale yellow
branching pattern of sporangiophores	unbranched below, furcate or trifurcate or scarcely unbranched in the fertile zone	unbranched below, unbranched, furcate or trifurcate in the fertile zone
length of a stipe of sporocladia (μm)	5.5-9.0 (7.3±0.9)	4.8-7
width of a stipe of sporocladia (μm)	5.0-7.0 (5.8±0.6)	3.8-4.4
shape of sporocladia	nearly parallel to the sporangiophore, arcuate	divergent, slightly sigmoid
No. of cells composing a sporocladium	7-11 (8±0.6)	4-8 av. 6
length of sporocladia (μm)	28.0-44.0 (34.3±2.9)	18-30 av.24
width of sporocladia (μm)	6.5-10.0 (7.5±0.4)	5-7
shape of apical cell of sporocladia	slightly tapering	tapering
shape of pseudophialides	flask-shaped	ellipsoid
length of pseudophialides (μm)	6.5-9.5 (6.9±0.4)	4-5.2
width of pseudophialides (μm)	2.5-5.0 (3.2±0.4)	2.2-3
shape of sporangiola	cylindrical, ventricosus	elongate oval-ovate, slightly arcuate
length of sporangiola (μm)	10.0-15.5 (12.0±0.4)	10-15.4 av.12.4
width of sporangiole (μm)	2.5-4.0 (2.9±0.2)	1.8-2.4
shape of sporangiospores	cylindrical, ventricosus	abruptly attenuated distally to form a spine-like process, rounded and truncate below
length of sporangiospores (μm)	9.5-14.0 (11.2±0.6)	8.8-13 av.10.5
width of sporangiospores (μm)	2.5-4.0 (2.9±0.2)	1.8-2.4

*: Differential characteristics are emphasized with shade.

Table 2-12. Comparative synopsis of *Coemansia* sp. 1 and *Coemansia erecta*.

characteristics*	*C.* sp. 1 on 1/2 ME-YE agar	*C.* '*erecta*' on PSA (Matsushima 1975)	*C. erecta* (Linder 1943)	*C. erecta* (kk0022) on 1/2 ME-YE agar
colonies	somewhat sulphur-yellow	sulphur-yellow	pallid yellow to bright yellow or 'Baryta Yellow'	pale-yellow
branching pattern of sporangiophores	unbranched below, furcate or trifurcate or scarcely unbranched in the fertile zone	unbranched or scantily branched	unbranched, furcate or trifurcate in the fertile zone	unbranched below, mainly furcate, sometimes trifurcate, and scarcely unbranched in the fertile zone
length of the stipe of sporocladia (μm)	5.5-9.0 (7.3±0.9)	4-11	3.5-7.2	3.5-6.0 (4.6±0.4)
width of the stipe of sporocladia (μm)	5.0-7.0 (5.8±0.6)	4-6.5	2.0-2.1	3.5-5.5 (3.8±0.4)
sporocladia	nearly parallel to the sporangiophore, arcuate	arcurate	divergent, slightly arcurate or somewhat sigmoid	divergent, slightly sigmoid
No. of cells composing a sporocladium	7-11 (8±0.6)	5-9	5-8	6-8 (7±0.4)
length of sporocladia (μm)	28.0-44.0 (34.3±2.9)	23-46	20-36	21.0-28.5 (24.0±1.6)
width of sporocladia (μm)	6.5-10.0 (7.5±0.4)	5-10	5.5-6.5	4.5-7.0 (5.2±0.5)
shape of the apical cell of sporocladia	slightly tapering	slightly tapering	somewhat tapering	slightly tapering
shape of pseudophialides	flask-shaped	flask-shaped	ovoid	flask-shaped
length of pseudo-phialides (μm)	6.5-9.5 (6.9±0.4)	5-7-(9)	3.5-6	4.0-5.5 (4.9±0.3)
width of pseudo-phialides (μm)	2.5-5.0 (3.2±0.4)	(1.8)-2-3-(3.4)	1.0-1.2	1.5-2.5 (1.5±0.2)
shape of sporangiola	cylindrical, ventricosus	cylindrical, ventricosus	cylindrical, not ventricosus	cylindrical, not ventricosus
length of sporangiola (μm)	10.0-15.5 (12.0±0.4)	7.5-12	6.5-9-(11)	6.0-8.5 (7.5±0.5)
width of sporangiola (μm)	2.5-4.0 (2.9±0.2)	2.3-3	1.5-2.5	1.5-2.5 (2.1±0.2)

*: Differential characteristics are emphasized with shade.

Table 2-13. Comparative synopsis of *Ramicandelaber brevisporus* (tentative name) and *Ramicandelaber longisporus*.

characteristics*	*R. brevisporus* (tentative name) 1/2 ME-YE agar	*R. longisporus* (type strain) on Miura agar (Ogawa et al. 2001)
colonies	pure glossy white, slow growing	white, relatively slow growing, effuse
vegetative hyphae	colorless, septate	colorless, septate
width of the hyphae (μm)	2.0-5.0 (2.8±0.1)	2.5-5
width of sporophores (μm)	8.0-24.0 (2.8±0.1)	7-10, (6-12 in age)
length of rhizoids (μm)	12.5-138.0 (50.9±2.7)	(9-) 15-22 (-36)
width of rhizoids (μm)	2.0-5.0 (3.1±0.1)	(1.5-) 2-4 (-6)
lateral branches	usually present	absent
No. of fertile branches per globose body	3-13 (8)	1-4
length of fertile branches (μm)	15.0-34.0 (25.8±0.4)	(8-) 11-13 (-15)
width of fertile branches (μm)	2.5-4.5 (3.5±0.1)	1.5-3.5
No. of sporocladia per fertile branch	2-9 (5)	-
length of sporocladia (μm)	6.5-10.0 (7.8±0.1)	(4-) 6-7 (-12) [(2-)5-6(-10) in age]
width of sporocladia (μm)	2.0-2.5 (2.4±0.0)	1-3 (1-2.5 in age)
length of pseudophialides (μm)	4.0-6.5 (4.9±0.1)	3-7 (3-5 in age)
width of pseudophialides (μm)	2.5-5.0 (3.5±0.1)	2-5 (in the case of subspherical one) (2-4 in age)
shape of spores	slender fusiform, acuminate, slightly curved	narrow fusiform, slightly curved
length of spores (μm)	17.5-25.0 (21.0±0.2)	(33-) 40-44 (-55)
width of spores (μm)	3.0-4.0 (3.8±0.0)	(3-) 5-6 (-9)

*: Differential characteristics are emphasized with shade.

Table 3-1. A clarification of morphological characteristics.

characteristics	criteria				
	A	B1	B2	B3	C
3.3.1 Asexual reproductive structures					
(1) Coiling of sporangiophores/sporophores	×	×	×	×	○
(2) Distribution patterns of sporocladia	×	×	×	×	△
(3) Whether pseudophialides or sporocladia are sporogeneous	○	×	×	×	×
(4) Whether sporocladia are septate or aseptate	○	○	×	×	×
(5) Whether a sporocladial cell generates a single or plural pseudophialides	○	×	×	×	×
(6) Orientation of pseudophialides	×	×	×	×	○
(7) Whether sporogeneous cells are monosporic or polysporic	○	×	×	×	×
(8) Whether asexual spores are sporangiospores or conidia	○	×	×	×	×
(9) Wet or dry nature of spores	×	×	×	×	○
3.3.2 Non-reproductive structures					
(10) Rhizoids of sporangiophores/sporophores	×	×	×	×	○
(11) Lateral branches	×	×	×	×	×
(12) Connections between aerial hyphae	○?	×	×	×	×
3.3.3 Sexual reproductive structures					
(13) The process of the formation of zygospores (zygosporogenesis)	×	×	×	×	×
(14) Surface ornamentation of zygospores	○	×	×	×	×
(15) Pigmentation of zygospore walls	○	×	×	×	×
(16) Contents of zygospores	○	×	×	×	×
(17) The attachment point of suspensors to zygospores	×	×	×	×	△

A: Characteristics to divide the Kickxellales *sensu lato* into groups.

B1: Characteristics for the recognition of the genera of the *Coemansia* group (= Kickxellales *sensu stricto*).

B2: Characteristics for the recognition of the genera of the *Spiromyces* group (= Spiromycetales, tentative name).

B3: Characteristics for the recognition of genera of the *Ramicandelaber* group (= Ramicandelaberales, tentative name).

C: Characteristics for the identification of the species of the *Coemansia* group (= Kickxellales *sensu stricto*).

○: applicable, △: partly applicable, ×: insufficient

Table 4-1. A comparison of the morphological grouping of the present study and the precedent typification.

typifications	the present study		preceding studies		
			Benjamin (1966)	Ogawa et al. (2001)	Young (1999)
main base of the typification	total morphology*	types of sporocladia	septation of sporocladia	septation of sporocladia	asexual sporogeneous apparates
Coemansia	*Coemansia* group	*Coemansia* type	septate type	septate type	the type of other genera
Dipsacomyces					
Kickxella			tri-septate type		
Martensella			septate type		
Martensiomyces					
Spirodactylon					*Spirodactylon* type
Linderina		*Linderina* type	aseptate type 1	aseptate type	*Linderina* · *Spiromyces* type
Myconymphaea		*Myconymphaea* type	–	–	–
Spiromyces	*Spiromyces* group	*Spiromyces* type	aseptate type 2	aseptate type	*Linderina* · *Spiromyces* type
*Mycoemilia***			–	–	–
Ramicandelaber	*Ramicandelaber* group	*Ramicandelaber* type	–	aseptate type	–

*: Groups based on the total morphology including sexual reproductive apparates. **: A tentative name of this undescribed genus.

Table 6-1. List of the fungi of which sequences were employed for the 18S rDNA analyses.

phylum	class	order	species	accession No.	strain No.
Fungi					
Chytridiomycota					
		Blastocladiales (2)			
			Allomyces macrogynus	U23936	–
			Blastocladiella emersonii	X54264	–
		Chytridiales (1)			
			Chytridium confervae	M59758	–
		Neocallimastigales (4)			
			Neocallimastix frontalis	M62704	–
			N. frontalis	X80341	–
			N. joyonii	M62705	–
			Neocallimastix sp.	M59761	–
		Spizellomycetales (1)			
			Spizellomyces acuminatus	M59759	–
		order unidentified (1)			
			Chytridiomycetes sp.	AAHL-97-8	–
		inc. sed. (1)			
			Piromonas communis	M62706	–
Zygomycota					
	Zygomycetes				
		Basidiobolales (1)			
			Basidiobolus ranarum	D29946	–
		Dimargaritales (3)			
			Dimargaris bacillispora	AB016020	–
			Dispira cornuta	AB016021	–
			Tieghemiomyces parasiticus	AB016022	–
		Endogonales (1)			
			Endogone pisiformis	X58724	–
		Entomophthorales (11)			
			Conidiobolus coronatus	D29947	–
			C. thromboides	AF052401	–
			Entomophaga aulicae	U35394	–
			Entomophthora muscae	D29948	–
			E. schizophorae	AF052402	–
			Eryniopsis ptycopterae	AF052403	–
			Macrobiotophthora vermicola	AF052400	–
			Pandora neoaphidis	AF052405	–

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(Entomophthorales)		
Strongwellsea castrans	AF052406	–
Zoophthora culisetae	D61381	–
Z. radicans	AF052404	–
Kickxellales (12)		
Coemansia braziliensis	AF007532	–
C. reversa	AF007533	–
Dipsacomyces acuminosporus	AF007534	–
Kickxella arabastrina	AF007537	–
Linderina pennispora	AF007538	–
Martensiomyces pterosporus	AF007539	–
Mycoemilia scoparia[*1,*2]	–	CBS 109375
Myconymphaea yatsukahoi[*1]	–	CBS 109376
Ramicandelaber brevisporus[*1,*2]	–	CBS 109374
R. brevisporus[*1,*2]	–	CBS 109373
Spirodactylon aureum	AF007541	–
Spiromyces aspiralis	AF007543	–
S. minutus	AF007542	–
Mortierellales (1)		
Mortierella polycephala	X89436	–
Mucorales (1)		
Mucor mucedo	X89434	–
M. racemosus	X54863	–
M. ramannianus	X89435	–
Syncephalastrum racemosum	X89437	–
Trichomycetes		
Harpellales (5)		
Capniomyces stellatus	AF007531	–
Furculomyces boomerangus	AF007535	–
Genistelloides hibernus	AF007536	–
Smittium culisetae	D29950	–
S. culisetae	AF007540	–
Choanoflagellida (6) (outgroups)		
Acanthocoepsis unguiculata	L10826	–
Diaphanoeca grandis	L10824	–
Monosiga brevicollis	AF100940	–
M. brevicollis	AF084618	–
Salpingoeca infusionum	AF100940	–
Sphaeroeca volvox	Z34900	–

[*1]: Sequences determined in the present study. [*2]: Tentative names.

Table 6-2. List of the fungi of which sequences were employed for the 28S rDNA analyses.

phylum	class	sub-class	order	species	accession No.	strain No.
Fungi						
Ascomycota (outgroups)						
		Eurotiomycetidae				
			Eurotiales (1)			
				Aspergillus niger	U28816	NRRL 348
		Saccharomycetidae				
			Saccharomycetales (2)			
				Pichia anomala	AF330113	CBS 24726
				Saccharomyces cerevisiae	AF005702	–
		Sordariomycetidae				
			Ophiostomatales (1)			
				Ophiostoma brevicolle	AF343678	–
			Sordariales (1)			
				Neurospora crassa	AF286411	–
Basidiomycota (outgroups)						
		Agaricomycetidae				
			Agaricales (1)			
				Lentinula edodes	AF261557	TMI 1941
			Dacrymycetales (1)			
				Dacrymyces stillatus	AF291309	–
		Tremellomycetidae				
			Tremellales (1)			
				Tremella moriformis	AF291374	–
Zygomycota						
	Zygomycetes					
			Basidiobolales (2)			
				Basidiobolus emersonii	X90411	–
				B. ranarum	AF113452	NRRL 20525
			Entomophthorales (2)			
				Conidiobolus coronatus	AF113456	NRRL 28638
				C. incongruus	AF113457	NRRL 28636

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Kickxellales (12)		
Coemansia braziliensis	AF031069	–
C. reversa	AF031067	–
Dipsacomyces acuminosporus	AF031065	–
Kickxella arabastrina	AF031064	–
Linderina pennispora	AF031063	–
Martensiomyces pterosporus	AF031066	–
Mycoemilia scoparia[*1, *2]	–	CBS 109375
Myconymphaea yatsukahoi[*1]	–	CBS 109376
Ramicandelaber brevisporus[*1, *2]	–	CBS 109374
R. brevisporus[*1, *2]	–	CBS 109373
Spirodactylon aureum	AF031068	–
Spiromyces aspiralis	AF031071	–
S. minutus	AF031070	–
Mortierellales (3)		
Mortierella chlamydospora	AF157197	–
M. verticillata	AF157199	–
Umbelopsis isabellina	AF157220	–
Mucorales (7)		
Absidia repens	AF113448	NRRL 1336
Apophysomyces elegans	AF113450	NRRL 28632
Choanephora cucurbitarum	AF157181	–
Cunninghamella echinulata	AF157184	–
Mucor indicus	AF113469	NRRL 28634
M. mucedo	AF113470	NRRL 3635
Syncephalastrum racemosum	AF113484	NRRL 2496
Trichomycetes		
Harpellales (4)		
Capniomyces stellatus	AF031073	–
Furculomyces boomerangus	AF031074	–
Genistelloides hibernus	AF031062	–
Smittium culisetae	AF031072	–

[*1]: Sequences determined in the present study. [*2]: Tentative names.