

## Aquatic fungi of Iraq: Species of *Achlya*

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**S u m m a r y.** — Eleven species of *Achlya* were isolated from the Shatt Al-Arab estuary. A complete description, illustrations and a proposed key for these species are included.

### Introduction

The genus *Achlya* belongs to the family Saprolegniaceae (Oomycetes). The members of this genus usually grow saprophytically in aquatic habitats, and their occurrence in freshwater of Shatt Al-Arab estuary has been discussed (RATTAN & al., 1980). Taxonomic studies on the other genera of Saprolegniaceae from Shatt Al-Arab estuary were carried out by RATTAN & al. (1979) and ISMAIL & al. (1979). Moreover, the relationship between saprolegnioid fungi, including *Achlya* species, and phytoplanktons in the same habitat has been given by AL-SAADY & al. (1979).

The most extensive taxonomic studies on *Achlya* were carried out by COKER (1923) and JOHNSON (1956). The method of isolation used follows that of RATTAN & al. (1980).

### *Achlya*

NEES, Nova Acta Acad. Leop.-Carol., 11: 514. 1823.

**T h a l l i** usually monoecious or rarely dioecious. — **H y p h a e** stout or rarely delicate, sparsely branched to branched, broader and thick-walled at the base but becoming progressively narrow and thin-walled towards the apices. — **G e m m a e** present or absent, when present may germinate directly by germ tube or zoosporangia or rarely into oogonia. — **Z o o s p o r a n g i a** variable in shape, being hyphoid to cylindrical, fusiform, naviculate or irregular, terminal or intercalary, renewed sympodially or basipetally but not by internal proliferation, **z o o s p o r e s** dimorphic, primary zoospores encysting at the mouth of the zoosporangium and forming a hollow sphere; secondary zoospores reniform, laterally biflagellate. Some species may exhibit

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thraustothecoid, dictyoid or aplanoid discharge of zoospores. — Oogonia terminal, lateral or intercalary, single or occasionally in chains; the walls smooth or sometimes ornamented, pitted or unpitted; oogonial stalk present or lacking, when present short to long. — Oospore one to many, centric to subcentric or eccentric. — Antheridial branches present or absent, when present declinuous to monoclinaous, androgynous or hypogynous; antheridial cells tubular or clavate, laterally or apically appressed, fertilization tubes present or absent.

Type: *Achlya prolifera* NEES.

The chief generic feature is the manner of discharge of zoosporangia. The primary zoospores encyst at the mouth of zoosporangium forming a hollow sphere which may or may not be persistent. Some species, however, do show dictyoid, thraustothecoid or aplanoid discharge of zoosporangia in addition to achlyoid.

It is a large genus and has often been segregated into a number of subgenera; but such subgeneric delimitations are not followed here.

### Key to the Species

1. Oospores centric or subcentric ..... 2
- 1\*. Oospores eccentric ..... 5
2. Oospores centric, usually 2—28 per oogonium and filling the cavity; oogonial wall smooth and sparsely pitted; antheridial branches androgynous to monoclinaous ..... 1. *A. racemosa*
- 2\*. Oospores subcentric ..... 3
3. Antheridial branches strictly declinuous; oospores usually less than 8 in number and large in size (40—62  $\mu$ m in diameter) ..... 2. *A. oblongata* var. *gigantica*
- 3\*. Antheridial branches androgynous to monoclinaous or hypogynous but not declinuous; oospores usually more than 8 (1—40 per oogonium) and comparatively smaller in size (less than 40  $\mu$ m in diameter) ..... 4
4. Oogonial wall usually marked with sparse papillate projections on the outside; antheridial branches monoclinaous or very rarely hypogynous or declinuous; zoospore discharge achlyoid to dictyoid ..... 3. *A. treleaseana*
- 4\*. Oogonial wall smooth; antheridial branches predominantly androgynous or occasionally monoclinaous; zoospore discharge achlyoid but never dictyoid ..... 4. *A. polyandra*
5. Thalli dioecious with antheridial and oogonial branches arising independently on separate thalli; oospores maturing, 2—21 per oogonium and usually filling the oogonial cavity; antheridial branches profusely branched and ramified .... 5. *A. ambisexualis*

- 5\*. Thalli monoecious with antheridial or oogonial branches arising from the same thallus ..... 6
- 6. Antheridial branches absent; oogonial wall with sparse papillate projections and unpitted to rarely pitted; oospores 2—26 per oogonium and usually filling the cavity . . 6. *A. aff. caroliniana*
- 6\*. Antheridial branches always present; oogonial wall smooth, with or without pits ..... 7
- 7. Primary zoosporangia exhibiting thraustothecoid discharge; oospore 2—8 per oogonium and not filling the cavity, antheridial branches declinous to monoclinalous ..... 7. *A. dubia*
- 7\*. Primary zoosporangia not exhibiting thraustothecoid discharge 8
- 8. Antheridial branches declinous to rarely androgynous, usually branched and coiling around hyphae which may or may not bear oogonia; wall usually pitted and oogonia contain 2—10 oospores ..... 8. *A. proliferoides*
- 8\*. Antheridial branches not coiling around hyphae as above ..... 9
- 9. Antheridial branches strictly declinous; oospores 3—31 per oogonium and 17—28  $\mu\text{m}$  in diameter; encysted primary zoospores in cluster often germinate directly by germ tubes ..... 9. *A. prolifera*
- 9\*. Antheridial branches not strictly declinous but may be monoclinalous or monoclinalous to declinous ..... 10
- 10. Antheridial branches always monoclinalous; oogonial wall usually unpitted ..... 10. *A. debaryana*
- 10\*. Antheridial branches monoclinalous to declinous (75% declinous); oogonial wall usually pitted at the point of contact with antheridia ..... 11. *A. klebsiana*

1. *Achlya racemosa* HILDEBRAND in Jahrb. Wiss. Bot. 6: 249. 1867—68. — Figs. 1—2.

*Mycelium* limited, usually dense but sparse in some isolates, 3-week old colonies 1—2.5 cm in diameter; primary hyphae 40—140  $\mu\text{m}$  wide at the base, sparsely branched at the base but branches become profuse towards the periphery, thin-walled, stout. — *Gemmae* abundant, variable in shape being spherical to cylindrical or irregular, single or in chains, terminal or lateral, rarely intercalary, germinating to produce zoosporangia or less commonly functioning as oogonia. — *Zoosporangia* abundant, cylindrical to fusiform or naviculate, 120—1100  $\times$  14—16  $\mu\text{m}$ , renewed sympodially; zoospore discharge achlyoid, spore cluster persistent and forming a more or less compact sphere of cysts (apparently not hollow); zoospore cysts 10—12  $\mu\text{m}$  in diameter, the walls thin, smooth. — *Oogonia* abundant, usually lateral or rarely terminal, spherical, 35—100 (145)  $\mu\text{m}$  in diameter the walls thin, 2—4  $\mu\text{m}$  broad, smooth, unpitted or pitted only at the point of contact within antheridia; oogonial stalk short (14  $\mu\text{m}$  long) to long (300  $\mu\text{m}$  long), 10—32  $\mu\text{m}$  broad, cylindrical, straight to rarely bent, thin but firm-walled — *Oospores* centric, 2—28 per oogonium, usually filling the oogonial cavity, spherical, 17—32  $\mu\text{m}$  in diameter, thin-walled, smooth, germination not seen. — *An-*

theridial branches androgynous to monoclinal sparsely branched or not, 7.5—18  $\mu\text{m}$  wide, thin-walled, persistent. Antheridial cells tubular to clavate, laterally or apically appressed.

Collections examined. — Ashar, Basrah, Jan., 1977, TMM 469; Abul-Khasib, Basrah, Jan., 1977, TMM 470; TMM 471; Qurna, Basrah, Feb. 1977, TMM 495; TMM 496; TMM 497; Ashar, Basrah, Feb., 1977, TMM 498; TMM 499; TMM 500; Qurna, Basrah, May, 1977, TMM 617; Ashar, Basrah, May, 1977, 618 TMM; TMM 619; TMM 620; Khora, Basrah, May, 1977, TMM 621; TMM 622.

This species is marked by centric oospores and androgynous to monoclinal antheridia. The oogonia are lateral with smooth walls. The pits are usually absent but sometimes may occur at the point of contact with antheridia.

2. *Achlya oblongata* var. *gigantica* FORBES in Trans. Brit. Mycol. Soc. 19: 231. 1935. — Figs. 3—4.

Mycelium limited, usually dense, 3-week old colonies 1—2 cm in diameter; primary hyphae 30—100  $\mu\text{m}$  wide, predominantly 45—60  $\mu\text{m}$  wide, moderately stout, profusely branched, with lateral branchlets arising in racemes, becoming progressively narrow towards the apices, thin-walled. — Gemmae not observed. — Zoosporangia few or sparse, (60) 100—400 (1050)  $\times$  20—45  $\mu\text{m}$ , subcylindrical to hyphoid, renewed sympodially; zoospore discharge achlyoid; spore cluster at the mouth of zoosporangia persistent; zoospore cysts 10—14  $\mu\text{m}$  in diameter, the walls thin, smooth. — Oogonia abundant, often arising at the ends of lateral branchlets forming a raceme, lateral or rarely terminal, ranging in shape from spherical (60—115  $\mu\text{m}$ ) to pyriform (100—160  $\times$  60—112  $\mu\text{m}$ ), the walls thin, smooth, unpitted; oogonial stalk 30—300  $\times$  12—30  $\mu\text{m}$ , cylindrical, straight to slightly curved, thin but firm-walled. — Oospores subcentric, 2—6 per oogonium, not filling the oogonial cavity, spherical 40—62  $\mu\text{m}$  in diameter, thin-walled, smooth, germination not seen. — Antheridial branches declinous, 7—14  $\mu\text{m}$  wide, simple to sparsely branched, not persistent. Antheridial cells tubular to clavate, laterally appressed, fertilization tubes not seen.

Collections examined. — Qurna, Basrah, Jan., 1977, TMM 443; TMM 444; TMM 445; Abul-Khasib, Basrah, Jan., 1977, TMM 446; TMM 447; TMM 448.

This species is marked by subcentric oospores and non-persistent, declinous antheridial branches. The oospores are usually less than 8 in number and comparatively large in size. These Iraqi isolates come very near to var. *gigantica* FORBES (1935) as redefined by JOHNSON (1956). The oospores in these isolates are even larger than those reported in the type specimen. *A. oblongata* var. *oblongata* is very similar but differs only in having comparatively smaller oospores.

3. *Achlya treleaseana* (HUMPHRY) KAUFMANN in Ann. Rept. Mich. Acad. Sci. Arts Letters 8: 26. 1906. — Figs. 5—7.

Mycelium limited, usually dense, 3-week old colonies 1—1.3 cm in diameter; primary hyphae (30) 50—110  $\mu\text{m}$  wide at the base, somewhat stout,

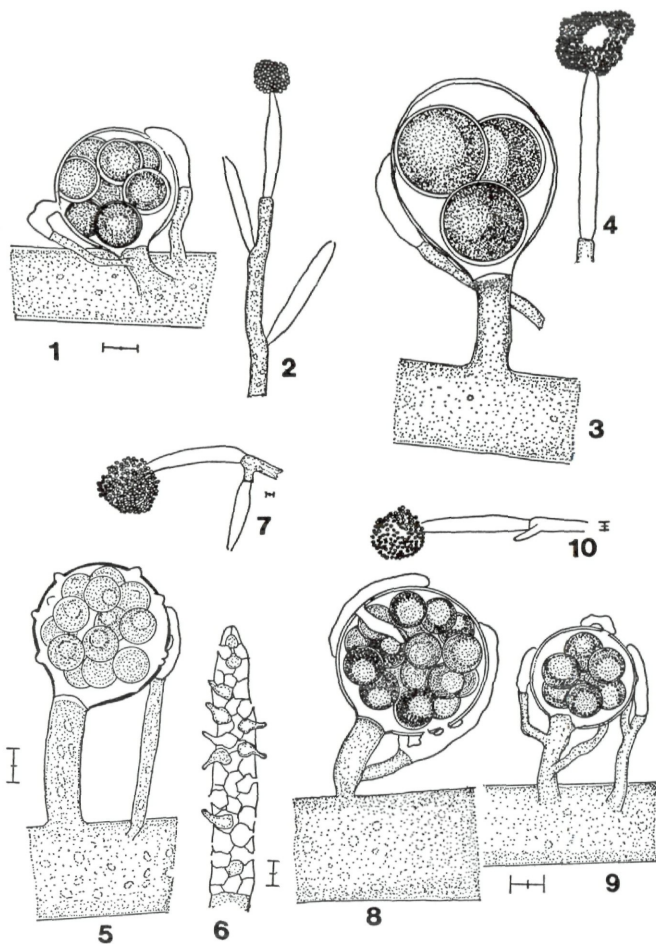


Fig. 1—10. *A. racemosa* (1—2): 1. Oogonium with centric oospores and androgynous to monoclinal antheridia. — 2. Achlyoid zoosporangia with sympodial renewal. — *A. oblongata* var. *gigantica* (3—4): 3. Oogonium with subcentric oospores and diclinous antheridia. — 4. Zoosporangium. — *A. treleaseana* (5—7): 5. Oogonium with subcentric oospores and monoclinous antheridia. — 6. Dictyoid zoosporangium. — 7. Achlyoid zoosporangia. — *A. polyandra* (8—10): 8, 9. Oogonia showing subcentric oospores and androgynous to monoclinous antheridia. — 10. Zoosporangium. (bar = 20  $\mu$ m).

sparsely, branches more common towards the periphery of the colony, thin-walled. — Gemmae rather scanty, terminal or intercalary, single or in chains, usually cylindrical to irregular,  $140-900 \times 40-60 \mu\text{m}$ , germinating to produce small zoosporangia. — Zoosporangia rather scanty, fairly common during the first two weeks but disappear later on, (90)  $280-900 \times 30-62 \mu\text{m}$ , cylindrical to subcylindrical, renewed sympodially; zoospore discharge achlyoid or occasionally dictyoid; spore cluster at the mouth of achlyoid zoosporangia not persistent; zoospore cysts  $11-13 \mu\text{m}$  in diameter, thin-walled, smooth. — Oogonia abundant, lateral to occasionally terminal, spherical,  $56-112 \mu\text{m}$  in diameter, predominantly  $62-98 \mu\text{m}$  in diameter, the walls thin, rarely smooth but usually marked with parse papillate projections on the outer surface, unpitted or sometimes pitted at the point of contact with antheridia, oogonial stalk  $30-140 \times 14-21 \mu\text{m}$ , cylindrical, straight, thin but firm-walled. — Oospores subcentric, 1-30 per oogonium, usually filling the oogonial cavity, spherical,  $18-42 \mu\text{m}$  in diameter, thin-walled, smooth, germination not seen. — Antheridial branches monoclinal to sometimes hypogynous or rarely dichinous,  $10-15 \mu\text{m}$  wide, simple to sparsely branched, usually not persistent. Antheridial cells tubular, laterally appressed, fertilization tubes not seen.

Collections examined. — Qurna, Basrah, Feb., 1977, TMM 501; TMM 502; Ashar, Basrah, Feb., 1977, TMM 503; Khora, Basrah, Feb., 1977, TMM 504; TMM 505; Abul-Khasib, Basrah, Feb., 1977, TMM 506; Qurna, Basrah, Feb., 1977, TMM 540; Khora, Basrah, Feb., 1977, TMM 541; TMM 542; Qurna, Basrah, April, 1977, TMM 570; Ashar, Basrah, April, 1977, 571; Khora, Basrah, April, 1977, TMM 572; TMM 573.

This species is marked by the subcentric oospores, presence of papillate projections on the outer oogonial wall and predominantly monoclinal antheridial branches. The zoosporangia are rather scarce and were observed only during the first two weeks. Older cultures were apparently without zoosporangia. The majority of zoosporangia showed achlyoid discharge while few having dictyoid discharge as well.

4. *Achlya polyandra* HILDEBRAND in Jahrb. Wiss. Bot. 6: 258. 1867—68. — Figs. 8—10.

Mycelium limited, usually dense, 3-4 week old colonies  $1.5-3 \text{ cm}$  in diameter; primary hyphae (40)  $60-150 \mu\text{m}$  wide at the base, stout, moderately branched, becoming progressively narrow towards the apices, thin-walled. — Gemmae abundant, variable in shape and often arranging from globose to fusiform, terminal or intercalary, single or in chains, thick-walled and tinted brown, with dense granular contents, germinating into zoosporangia. — Zoosporangia abundant, hypoid to somewhat fusiform or subcylindrical,  $90-980 \times 22-60 \mu\text{m}$ , renewed sympodially; zoospore discharge achlyoid; spore cluster persistent at the mouth of zoosporangia; zoospore cysts (7)  $10-12 \mu\text{m}$  in diameter, the walls thin, smooth. — Oogonia abundant, lateral, spherical to subspherical,  $56-115 (145) \mu\text{m}$  in diameter, the walls thin, smooth, unpitted or pitted only at the point of contact with antheridia; oogonial stalk straight to slightly bent,  $25-290 \times 14-28 \mu\text{m}$ , thin-walled, stout. — Oospores subcentric 1-40 per oogonium, generally 8-16 in number, usually filling the oogonial cavity, spherical,  $15-28 \mu\text{m}$  in diameter, thin-walled, smooth, germination not observed. — Antheridial branches androgynous to occasionally monoclinal, moderately branched,

7—15  $\mu\text{m}$  wide, thin-walled, persistent; antheridial cells tubular to clavate, laterally appressed, fertilization tubes not seen.

Collections examined. — Qurna, Basrah, Dec., 1976, TMM 396; TMM 397; TMM 398; Qurna, Basrah, Jan., 1977, TMM 449; TMM 450; TMM 451; TMM 452; TMM 453; TMM 454; TMM 455; TMM 456; Ashar, Basrah, Jan., 1977; TMM 457; TMM 458; TMM 459; TMM 460; Khora, Basrah, Jan., 1977, TMM 461; TMM 462; TMM 463; TMM 464; Abul-Khasib, Basrah, Jan., 1977, TMM 465; Qurna, Basrah, March, 1977, TMM 543; TMM 544; Ashar, Basrah, March, 1977, TMM 545; TMM 546; Qurna, Basrah, April, 1977, TMM 615.

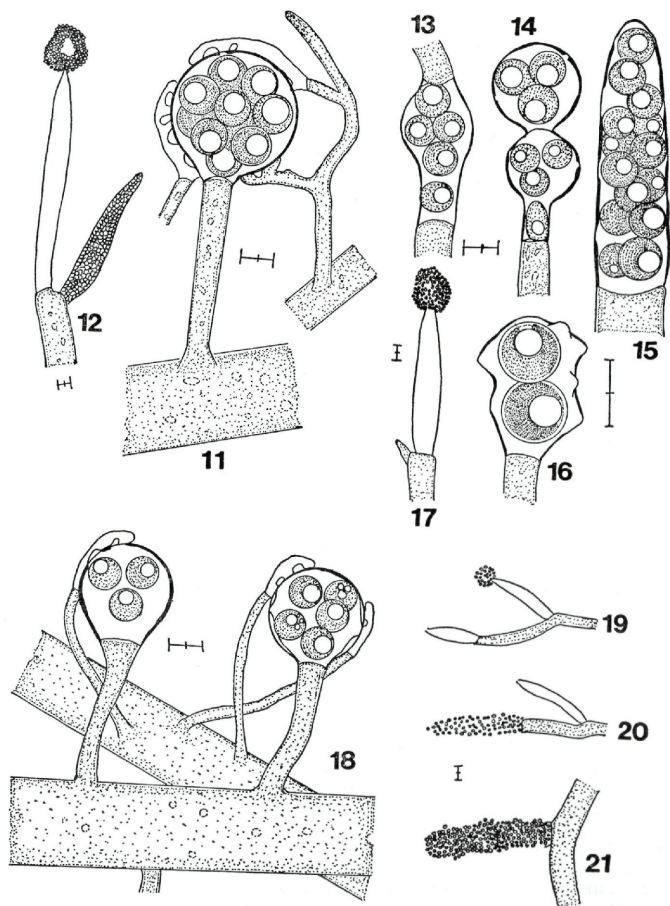
This species is marked by subcentric oospores, smooth oogonial wall and androgynous to occasionally monoclinal antheridial branches. JOHNSON (1956) recorded that oogonial stalks are longer (usually 2—5 times the diameter of oogonia) but in the Iraqi isolates some were definitely smaller (less than the diameter of oogonia), while in others they were longer (more than twice the diameter of oogonia). This feature was found to be variable.

5. *Achlya ambisexualis* RAPER in Amer. Journ. Bot. 26: 639. 1939. — Figs. 11—12.

Thalli dioecious; antheridial and oogonial branches arise independently. — Mycelium of oogonial thallus dense, 4-week old colony on hemp seed 1.5—2 cm in diameter; primary hyphae 75—170  $\mu\text{m}$  wide at the base (usually 40—60  $\mu\text{m}$  broad at the tip), sparsely branched, thin-walled but stout. Mycelium of the antheridial thallus dense, 4-week old colonies 1.5—2 cm in diameter; primary hyphae 40—100  $\mu\text{m}$  wide at the base (usually 15—30  $\mu\text{m}$  wide at the tips), profusely branched and anastomosing, thin but firm walled. — Gemmae in oogonial thalli common, usually spherical, 40—100  $\mu\text{m}$ , intercalary or terminal, single or sometimes in chains, germinating to produce zoosporangia. Gemmae in antheridial thalli not observed. — Zoosporangia in oogonial thalli abundant, 210—700  $\times$  20—50  $\mu\text{m}$ , fusiform to subcylindrical, renewed sympodially; zoospore discharge achlyoid; zoospore cysts persistent at the mouth of zoosporangium, or falling away in part or as a whole; zoospore cysts 9—11  $\mu\text{m}$  in diameter, smooth, thin-walled. Zoosporangia in antheridial thalli sparse, fusiform to subcylindrical, 140—325  $\times$  14—21  $\mu\text{m}$  (other details as in zoosporangia in oogonial thalli). — Oogonia abundant, usually spherical to subcylindrical, rarely pyriform, 55—100  $\mu\text{m}$  across the walls, thin, smooth, pitted at the point of contact with antheridial cells only, usually lateral; oogonial stalk 60—150  $\times$  14—21  $\mu\text{m}$ , straight, cylindrical, thin but firm-walled. — Oospores eccentric, 2—21 per oogonium, usually filling the oogonial cavity, spherical, 2—30  $\mu\text{m}$  in diameter, thin-walled, smooth, germination not observed. — Antheridial branches profusely branched and often enveloping the oogonia, 8—15  $\mu\text{m}$  wide, thin-walled, persistent. Antheridial cells tubular, encircling oogonia.

Collections examined. — Ashar, Basrah, June, 1977, TMM 642, TMM 643; Ashar, Basrah, July, 1977, TMM 662; TMM 663; TMM 664; TMM 665.

This species is marked by the eccentric oospores and dioecious thalli. The oospores are of maturing type and usually fill the oogonial



Figs. 11—21. *A. ambisexualis* (11—12). Oogonium showing eccentric oospores and enveloped antheridial branches arising from another thallus. — 12. Zoosporangia. — *A. aff. caroliniana* (13—17): 13, 14, 15, 16. Different types of oogonia with eccentric oospores. — 17. Zoosporangium. — *A. dubia* (18—21): 18. Oogonia showing eccentric oospores and declinuous antheridia. — 19. Zoosporangia with achlyoid zoospores discharge. — 20, 21. Thraustothecoid zoosporangia. (bar = 20  $\mu$ m).



cavity. This feature serves to distinguish this species from the related *A. bisexualis* COKER & COUCH. The Iraqi isolates are very typical of the species and resemble it in most respects.

6. *Achlya* aff. *caroliniana* COKER in Bot. Gaz. 50: 381. 1910. — Figs. 13—17.

*Mycelium* limited, usually dense, 3-week old colonies on hemp seeds 0.8—1 cm in diameter; primary hyphae 58—116  $\mu\text{m}$  broad at the base but becoming progressively narrow towards the apices (usually 35—60  $\mu\text{m}$ ), not or sparsely branched, thin but firm walled. — *Gemmae* not observed. — *Zoosporangia* common, but not abundant, 200—870  $\times$  30—50  $\mu\text{m}$ , sub-cylindrical to subfusiform, usually straight, renewed sympodially or in basipetal succession; zoospore discharge achlyoid, spore cluster at the mouth of zoosporangium persistent; zoospore cysts spherical, smooth, thin-walled, ca. 9—11  $\mu\text{m}$  in diameter. — *Oogonia* abundant, spherical (40—98  $\mu\text{m}$  diam.) to subcylindrical to sometimes irregular (may exceed 200  $\mu\text{m}$  in length), terminal or rarely intercalary, usually single or sometimes in chains, the walls thin, unpitted or rarely pitted, usually with sparse but distinct papillate projections on the outer wall, projections abundant on some but rare or absent on the other oogonia. Oogonial stalk short, sometimes absent. — *Oospores* eccentric, 2—26 per oogonium, usually filling the cavity, spherical, 17—25  $\mu\text{m}$  in diameter, moderately thin-walled, germination not seen. — *Antheridial branches* absent.

*Collections examined.* — Qurna, Basrah, Jan., 1977, TMM 466; TMM 467; TMM 468.

This species is marked by eccentric oospores, absence of antheridial branches and sparsely papillate oogonial wall. The oogonia are irregular in shape, with or without stalk and possess 2—26 oospores. These collections resemble *A. caroliniana* in several details but differ in having a large number of oospores per oogonium. In these isolates the predominant number of zoospores per oogonium is 12—23 while in *A. caroliniana* it is 1—4 (maximum 1—12).

7. *Achlya dubia* COKER in Saprolegniaceae, 135. 1923. — Figs. 18—21.

*Mycelium* limited, usually dense, 3-week old colonies on hemp seeds 1—1.5 cm in diameter; primary hyphae 40—100  $\mu\text{m}$  wide at the base, stout, moderately branched, especially towards the periphery. — *Gemmae* not observed. — *Zoosporangia* abundant, fusiform to sub-cylindrical, 150—300  $\times$  14—30  $\mu\text{m}$ , renewed sympodially; zoospore discharge thraustothecoid in primary zoosporangia but achlyoid to aplanoid in secondary or later formed zoosporangia; spore cluster in achlyoid zoosporangia not persistent; zoospore cysts 10—12  $\mu\text{m}$  in diameter. — *Oogonia* less common to common, sometimes abundant, spherical to subspherical, 40—70  $\mu\text{m}$  in diameter, the walls thin, smooth, unpitted or with occasional pits at the point of contact with antheridia; oogonial stalk 60—140  $\times$  10—18  $\mu\text{m}$ , straight, thin but firm-walled. — *Oospores* eccentric, 2—8 per oogonium, usually not filling the oogonial cavity, spherical, 14—25  $\mu\text{m}$  in diameter, thin-walled, smooth, germination not seen. — *Antheridial branches* declinuous to monoclinal, sparsely branched, 5—10  $\mu\text{m}$  wide, thin-walled, persistent. Antheridial cells tubular, laterally appressed, fertilization tubes not observed.

Collections examined. — Ashar, Basrah, Sept., 1976, TMM 308; Abul-Khasib, Basrah, Sept., 1976, TMM 309; Qurna, Basrah, October, 1976, TMM 343; TMM 344; Qurna, Basrah, Nov., 1976, TMM 360; Qurna, Basrah, Aug., 1977, TMM 674; TMM 675; Ashar, Basrah, Aug., 1977, TMM 676; TMM 677.

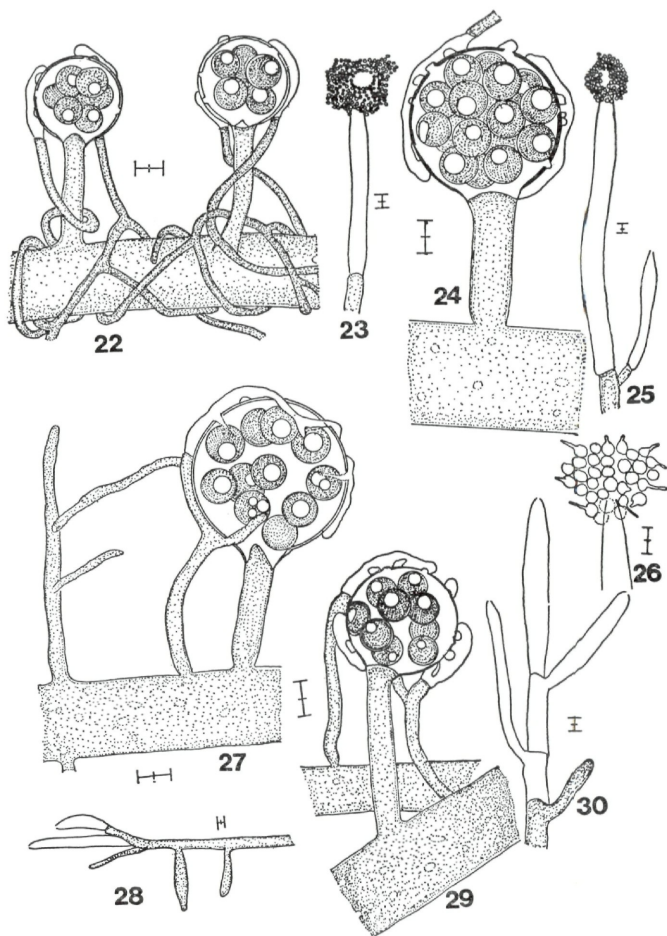
This species is marked by eccentric oospores and declinuous to monoclinoous antheridial branches. The discharge of zoosporangia is variable. In young colonies primary zoosporangial discharge is always thraustothecoid, but secondary zoosporangia or later formed ones show achyloid or aplanoid discharge. Since the thraustothecoid discharge is very typical of the species and is of diagnostic value, their absence (in older cultures) makes a correct identification difficult. In the absence of thraustothecoid zoosporangia this species is keyed out near *A. prolifera* but differs in the number of oospores.

8. *Achlya proliferoides* COKER in Saprolegniaceae, 115. 1923. — Figs. 22—23.

Mycelium limited, usually dense, 4-week old colony on hemp seeds up to 1 cm in diameter; primary hyphae 60—115  $\mu$ m wide at the base, stout, thin but firm walled, sparsely branched in the basal part but branches becoming more profuse towards the periphery. — Gemmae abundant, usually spherical to ovoid, single or in chains, terminal or intercalary, often germinating by slender hyphae which release zoospore at their tips. — Zoosporangia abundant, mostly arising from the gemmae, filiform to subcylindrical, usually curved, 200—280  $\times$  25—35  $\mu$ m, renewed basipetally; zoospore discharge achyloid, spore cluster persistent; encysted zoospores 9—12  $\mu$ m in diameter, spherical, the walls thin, smooth. — Oogonia rather sparse, lateral, spherical to subspherical, 69—140  $\mu$ m in diameter, the walls thin (2.5—3.5  $\mu$ m thick), smooth, pitted; oogonial stalk 60—290  $\times$  14—30  $\mu$ m, straight, cylindrical, with thin but firm walls. — Oospores eccentric, 2—10 per oogonium, usually not filling the oogonial cavity, spherical, 17—32  $\mu$ m in diameter, thin-walled (3  $\mu$ m thick), smooth, germination not seen. — Antheridial branches declinuous, rarely androgynous, usually branched and coiling around the hyphae which may or may not bear oogonia, thin-walled, persistent. Antheridial cells tubular, often coiling around the oogonium, fertilization tube not seen.

Collections examined. — Qurna, Basrah, Nov., 1976, TMM 361; TMM 362; TMM 363; Qurna, Basrah, Dec., 1976, TMM 399; TMM 400; Qurna, Basrah, April, 1977, TMM 574; TMM 575; TMM 576; Qurna, Basrah, May, 1977, TMM 623; TMM 624.

This species is characterized by eccentric oospores and nature of antheridial branches. These are mostly declinuous and usually coiled around extensively on wider hyphae which may or may not bear oogonia. Although this feature is very distinctive and is the main diagnostic character of this species, JOHNSON (1956) reported that old subcultures have a tendency to lose this character and such isolates are



Figs 22—30. *A. proliferoides* (22—23): 22. Oogonia with eccentric oospores and hyphae encircled by antheridial branches. — 23. Zoosporangium. — *A. prolifera* (24—26): 24. Oogonium with eccentric oospores and declinous antheridia. — 25. Zoosporangia. — 26. Zoospore cysts germinating in situ at the mouth of the zoosporangium. — *A. debaryana* (27—28): 27. Oogonium with eccentric oospores and monoclinous antheridia. — 28. Zoosporangia. — *A. klebsiana* (29—30): 29. Oogonium with eccentric oospores and declinous antheridia. — 30. Sympodial zoosporangia. (bar = 20  $\mu$ m).

difficult to distinguish from the related species (not showing this coiling feature) viz. *A. flagellata* COKER, *A. prolifera* NEES, ect.

9. *Achlya prolifera* NEES in Nova Acta Acad. Leop.-Carol. 11: 514. 1823. — Fig. 24—26.

*Mycelium* limited, sparse to dense, 3-week old colonies on hemp seeds 1—1.5 cm in diameter; primary hyphae stout, 60—145  $\mu$ m wide at the base, sparsely branched, thin but firm walled. — *Gemmae* abundant, variable in shape, globose to ovoid or irregular, single or in chains, intercalary or sometimes terminal, germinating to produce zoosporangia. — *Zoosporangia* rare to abundant in some isolates, filiform to fusiform, sometimes naviculate, 140—700  $\times$  14—50  $\mu$ m, renewed sympodially; *zoospore* discharge achlyoid, spore cluster at the mouth of zoosporangium, persistent; *zoospore* cysts 8—11  $\mu$ m in diameter, thin-walled, smooth. The encysted primary zoospore cysts 8—11  $\mu$ m in diameter, thin-walled, smooth. The encysted primary zoospores in spore cluster were often seen to germinate by germ tubes. — *Oogonia* abundant, but less common in some isolates, usually lateral, sometimes terminal or rarely intercalary, spherical, subspherical or ovoid, 98—125  $\times$  62—95  $\mu$ m, the walls thin, smooth, pitted, oogonial stalk 30—300  $\times$  12—28  $\mu$ m, straight, thin but firm-walled, cylindrical. — *Oospores* eccentric, 3—31 per oogonium, usually filling the oogonial cavity, spherical, 17—28  $\mu$ m in diameter, thin-walled, smooth, germination not seen. — *Antheridial branches* declinuous, branched but irregular, wrapping around the oogonial stalk, 7—18  $\mu$ m wide, thin-walled, persistent. Antheridial cells tubular, encircling completely the oogonia, sometimes laterally appressed, fertilization tubes not seen.

*Collections examined.* — Khora, Basrah, Oct., 1976, TMM 345; TMM 346; Khora, Basrah, April, 1977, TMM 577; TMM 578; Abul-Khasib, Basrah, April, 1977, TMM 579; TMM 580; TMM 581; Qurna, Basrah, May, 1977; TMM 625; TMM 626; TMM 627; Abul-Khasib, Basrah, May, 1977, TMM 628; TMM 629; Qurna, Basrah, June, 1977, TMM 645; TMM 646; TMM 647; TMM 648; TMM 649; TMM 649; TMM 650; Qurna, Basrah, Aug., 1977, TMM 678; TMM 679; TMM 680.

This species is marked by eccentric oospores and strictly declinuous antheridial branches which usually coil around oogonial stalks. It comes very close to *A. americana* and *A. klebsiana*, but in both of these species the antheridial branches are not strictly declinuous and they do not coil around the oogonial stalks. Moreover, in *A. prolifera* the encysted zoospores at the mouth of zoosporangium germinate in situ by germ tubes.

10. *Achlya debaryana* HUMPHREY in Trans. Amer. Phil. Soc. (n. s.) 17: 117. 1893. — Figs. 27—28.

*Mycelium* limited, sparse to somewhat dense, 4-week old colonies on hemp seeds 1.5—2 cm in diameter, primary hyphae 85—170  $\mu$ m wide at the base but becoming progressively narrow towards the apices (40—60  $\mu$ m), stout, sparsely branched at the base, but branches becoming more profuse towards the periphery, thin but firm-walled. — *Gemmae* rather uncom-

mon, usually sub-cylindrical,  $140-700 \times 60-150 \mu\text{m}$ , terminal or intercalary, single or occasionally in chains. — Zoosporangia fusiform to naviculate, (120)  $280-900 \times 25-60 \mu\text{m}$ , renewed sympodially or basipetally; zoospore discharge achlyoid; spore cluster at the mouth of zoosporangium not persistent; zoospore cysts  $1-12 \mu\text{m}$  in diameter, smooth, thin-walled. — Oogonia abundant, lateral, usually forming a raceme, spherical,  $55-100 \mu\text{m}$  in diameter, the walls thin, smooth, unpitted or very rarely pitted at the point of contact with antheridia; oogonial stalk  $50-200 \times 10-12 \mu\text{m}$ , straight, cylindrical, sometimes slightly curved, thin but firm-walled. — Oospores eccentric,  $5-40$  per oogonium, usually not filling the oogonial cavity, spherical,  $18-28 \mu\text{m}$  in diameter, thin-walled, smooth, germination not observed. The oogonia and oospores were brownish then turned yellow at maturity. — Antheridial branches monoclinal, abundant, usually simple or occasionally branched, branches somewhat irregular, thin-walled, persistent. Antheridial cells tubular to occasionally clavate, laterally appressed, fertilization tubes present and pronounced.

Collections examined. — Qurna, Basrah, April, 1977, TMM 582; TMM 583; TMM 584; TMM 585; Qurna, Basrah, May, 1977, TMM 638.

This species is marked by the eccentric oospores, monoclinal antheridial branches and unpitted oogonial wall. This species is very similar to *A. americana* and perhaps both are synonyms. JOHNSON (1956), however, prefers to keep them separate on the basis of unpitted oogonial wall and monoclinal antheridial branches of remote region (in *A. debaryana*). The Iraqi isolates show more similarities with *A. debaryana* than with *A. americana*.

11. *Achlya klebsiana* PIETERS in Bot. Gaz. 60: 416. 1915. — Figs. 29—30.

Mycelium unlimited, sparse to sometimes dense, 3-week old colonies on hemp seed  $1-2 \text{ cm}$  in diameter; primary hyphae  $40-90 \mu\text{m}$  wide at the base, sparsely branched but branches become more profuse near the periphery, thin but firm-walled, usually the primary hyphae become tinted brown near the base. — Gemmae abundant, variable in shape and may be spherical to oval or cylindrical, sometimes irregular, single or in chains, terminal or sometimes intercalary, germinating to produce zoosporangia. — Zoosporangia usually abundant, cylindrical to fusiform,  $140-770 \times 25-55$  (70)  $\mu\text{m}$ , renewed sympodially or sometimes basipetalous; zoospore discharge achlyoid; spore cluster at the mouth persistent; zoospore cysts  $10-12 \mu\text{m}$  in diameter, thin-walled, smooth. — Oogonia abundant, usually lateral, spherical to subspherical,  $45-90 \mu\text{m}$  in diameter, the walls thin ( $1.5-3 \mu\text{m}$ ), smooth, unpitted or usually pitted at the point of contact with antheridial cells; oogonial stalks straight, cylindrical,  $50-240 \times 14-30 \mu\text{m}$ , thin but firm-walled. — Oospores eccentric,  $1-12$  per oogonium, generally not filling the oogonial cavity, spherical,  $16-29 \mu\text{m}$  in diameter, smooth, germination not seen. — Antheridial branches declinal (75%) to monoclinal, sparsely to profusely branched, branches somewhat irregular and uneven, thin-walled,  $8-22 \mu\text{m}$  wide, persistent. Antheridial cells tubular, often encircling the oogonia, fertilization tubes not seen.

Collections examined. — Khora, Basrah, Sept., 1976, TMM 310; Abul-Khasib, Basrah, Sept., 1976, TMM 311; TMM 312; Abul-

Khasib, Basrah, Oct., 1976, TMM 326; Ashar, Basrah, Nov., 1976, TMM 364; TMM 365; Abul-Khasib, Basrah, Nov., 1976, TMM 367; TMM 368; TMM 369.

This species is marked by eccentric oospores and predominantly declinuous antheridial branches. Some of the antheridial branches are definitely monoclinal and this feature serves to distinguish it from *A. prolifera*, which possesses strictly declinuous branches only. In *A. americana* the oogonial wall is more densely pitted and the antheridial branches are predominantly monoclinal. However, these species are very similar (JOHNSON, 1956).

*Achlya* sp. (sterile). 39 isolates of *Achlya* failed to produce oogonia and remained sterile.

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