VII. FUNGAL PATHOGENS, EXCEPT *COELOMOMYCES*, OF CULICIDAE (MOSQUITOS)[a]

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FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Aedes sp.	Larvae	Culicinomyces sp.		Australia	Lab.	Sweeney et al. (1973)
" "	Larvae	Saprolegnia sp.				Jettmar (1947)[b]
Aedes (Stegomyia) sp.	Larvae	Saprolegnia sp.				Martini (1920)[b]
Aedes sp.	Larvae	Smittium culisetae[a]		Japan	Field	Williams & Lichtwardt (1972)
Aedes aegypti	Larvae	Amoebidium parasiticum[a]		Puerto Rico	Lab. & field	Kuno (1973)
" "	Larvae, adults	Beauveria bassiana	0 (L) 100 (A)	USA (California)	Lab.	Clark et al. (1967,1968)
" "	Larvae	Beauveria tenellae	100	" "	Lab.	Pinnock et al. (1973), Sanders (1972)
" "	Larvae	Fusarium sp?		Ghana	Field	Macfie (1917)[c]
" "	Larvae	Lagenidium giganteum (= L. culicidum)	100	USA (North Carolina, Georgia)	Lab.	Couch & Romney (1973), McCray et al. (1973a), Umphlett (1973)
" "	Larvae	Metarrhizium anisopliae	100	USA (New York) France	Lab.	Roberts (1970,1974), Roberts & Mouchet (unpublished)
" "	Larvae	Smittium culicis[a]	High	USA (Kansas)	Lab.	Williams & Lichtwardt (1972)
" "	Larvae	Smittium culisetae[a]	High	USA (Kansas)	Lab.	Williams & Lichtwardt (1972)
" "	Larvae	Smittium (= Rubetella) inopinata[a]	93-100	Italy	Lab.	Coluzzi (1966)
" "	Larvae	Smittium simulii[a]	High	USA (Kansas)	Lab.	Williams & Lichtwardt (1972)
" "	Adults	Yeast				Christophers (1952), Marchoux, Salimbeni & Simond (1903)[b]

[a] Trichomycete. Does not penetrate host cells. Attached to external exocuticle (Amoebidium) or commensal in gut (Smittium). Causes mortality in stressed individuals only.

[b] Cited in Jenkins (1964).

[c] Cited in Jenkins (1964). Summary seen.

[d] Cited in Jenkins (1964). Original seen.

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Aedes albopictus	Larvae	Smittium culisetae[a]		USA (Hawaii)	Field	Williams & Lichtwardt (1972)
Aedes atropalpus epactius	Larvae	Culicinomyces clavosporus		USA (North Carolina)	Lab.	Couch et al. (1974)
Aedes atropalpus epactius	Larvae	Lagenidium giganteum		USA (North Carolina)	Lab.	Couch & Romney (1973)
Aedes atropalpus	Larvae	Metarrhizium anisopliae	100	USA (New York)	Lab.	Roberts (1970,1974)
Aedes australis	Larvae	Culicinomyces sp.		Australia	Lab.	Sweeney (1975a)
Aedes berlandi	Larvae	Saprolegnia declina		France	Lab.	Rioux & Achard (1956)[b]
" "	Larvae	Smittium culicis[a]		France	Field	Manier (1969)
" "	Larvae	Smittium culicis[a]	100	France	Lab.	Tuzet et al. (1961)
Aedes canadensis	Larvae, pupae	Entomophthora aquatica	0-80	USA (Connecticut)	Field	Anderson & Ringo (1969)
Aedes caspius	Larvae	Smittium culicis[a]		France	Field	Manier (1969)
Aedes communis (= Culex nemorosus)	Adults	Entomophthora conglomerata (= Empusa conglomerata, E. thaxteri)				Lakon (1919)[d], Sorokin (1877)[d]
Aedes detritus	Larvae	Amoebidium parasiticum[a]		Tunisia	Field	Manier et al. (1964)
" "	Adults	Entomophthora culicis				Marshall (1938)[b]
" "	Larvae	Fusarium oxysporum	>80 (lab.)	France	Lab. & field	Hasan & Vago (1972)
" "	Larvae	Smittium culicis[a]		France	Field	Manier (1969)
" "	Larvae	Smittium culicis[a]	100		Lab.	Tuzet et al. (1961)
Aedes dorsalis	Larvae	Beauveria tenella	100	USA (California)	Lab.	Pinnock et al. (1973), Sanders (1972)
Aedes geniculatus	Larvae	Saprolegnia sp.				Marshall (1938)[b]
" "	Larvae	Smittium culicis[a]		France	Field	Manier (1969)

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Aedes geniculatus	Larvae	Smittium culicis[a]	100		Lab.	Tuzet et al. (1961)
Aedes hexodontus	Larvae	Beauveria tenellae	100	USA (California)	Lab.	Pinnock et al. (1973)
Aedes mediovittatus	Larvae	Lagenidium giganteum (= L. culicidum)	100	USA (Georgia)	Lab.	McCray et al. (1973a), Umphlett (1973)
Aedes melanimon	Larvae	Smittium (= Rubetella) culicis[a]		USA (California)	Field	Clark et al. (1963)
Aedes nigromaculis	Larvae, adults	Beauveria bassiana	0 (L) 100 (A in lab.) 58 (A in field test)	USA (California)	Lab & field	Clark et al. (1967,1968)
" "	Larvae	Lagenidium giganteum	100	USA (California)	Field	McCray et al. (1973b)
Aedes polynesiensis	Larvae	Lagenidium giganteum		USA (North Carolina)	Lab.	Couch & Romney (1973)
" "	Larvae	Metarrhizium anisopliae		France	Lab.	Mouchet (unpublished)
Aedes rupestris	Larvae	Culicinomyces sp.	High	Australia	Field	Sweeney & Panter (1974)
Aedes rusticus	Larvae	Saprolegnia sp.				Marshall (1938)[b]
Aedes sierrensis	Larvae, adults	Beauveria bassiana	0 (L) 100 (A)	USA (California)	Lab. & field	Clark et al. (1967,1968)
" "	Larvae	Beauveria tenellae	100 53-71 26-91	USA (California)	Lab. Field Field	Pinnock et al. (1973) Sanders (1972)
" "	Larvae	Pythium sp. (near P. adhaerens)		USA (California)	Field & lab.	Clark et al. (1966)
Aedes sollicitans	Adults	Basidiomycete		USA (Louisiana)	Field	Chapman et al. (1967,1969)
" "	Larvae	Lagenidium giganteum (= L. culicidum)	100	USA (Georgia)	Lab.	McCray et al. (1973a), Umphlett (1973)

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Aedes sollicitans	Larvae	Metarrhizium anisopliae	100 (lab.) 98 field	USA (New York, Delaware)	Lab. & field	Roberts (1970,1974)
Aedes sticticus	Larvae	Smittium culicis[a]		USA (Wyoming)	Field	Williams & Lichtwardt (1972)
Aedes taeniorhynchus	Adults	Conidiobolus coronatus (= Entomophthora coronata)	76 (36% control mortality)	USA (Florida)	Lab.	Lowe & Kennel (1972)
" "	Larvae	Lagenidium giganteum (= L. culicidum)	100	USA (Georgia)	Lab.	McCray et al. (1973a), Umphlett (1973)
" "	Larvae	Metarrhizium anisopliae	100	USA (New York)	Lab.	Roberts (1970,1974)
Aedes triseriatus	Larvae	Lagenidium giganteum (= L. culicidum)	100	USA (Georgia)	Lab.	McCray et al. (1973a), Umphlett (1973)
" "	Larvae	Lagenidium giganteum		USA (North Carolina)	Lab.	Couch & Romney (1973)
" "	Larvae	Pythium sp. (near P. adhaerens)		USA (California)	Lab.	Clark et al. (1966)
" "	Larvae	Smittium culisetae[a]		USA (Kansas)	Lab.	M. E. Chapman (cited in Williams & Lichtwardt, 1972)
" "	Larvae	Smittium simulii[a]		USA (Kansas)	Lab.	M. E. Chapman (cited in Williams & Lichtwardt, 1972)
Aedes vexans	Larvae	Smittium culisetae[a]		USA (Hawaii)	Field	Williams & Lichtwardt (1972)
Aedes vittatus	Larvae	Smittium (= Rubetella) inopinata[a]	High	Italy	Field	Coluzzi (1966)
Anopheles sp.	Larvae	Aspergillus sp.				Christophers (1952)[b]
" "	Larvae	Aspergillus glaucus	High		Lab.	Speer (1927),[b] Galli-Valerio & Rochaz de Jongh (1905)[d]
" "	Larvae	Aspergillus niger	High		Lab.	Galli-Valerio & Rochaz de Jongh (1905),[d] Speer (1927)[b]

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Anopheles sp.	Larvae	Lagenidium giganteum	5 (lab.) 8 (field)	USA (North Carolina)	Lab. Field	Umphlett & Huang (1972), Umphlett (1973), Umphlett & McCray (1975)
" "	Larvae	Mucor stolonifera	Low	USSR	Lab.	Bačinskij (1926)[c]
" "	Larvae	Oidium lactis	Low	USSR (Leningrad)	Lab.	Bačinskij (1926)[c]
" "	Larvae	Penicillium glaucum	Low	USSR (Leningrad)	Lab.	Bačinskij (1926)[c]
" "	Larvae	Saprolegnia sp.				Jettmar (1947)[b]
Anopheles albimanus	Larvae, adults	Beauveria bassiana	100	USA (California)	Lab.	Clark et al. (1967,1968)
" "	Larvae	Metarrhizium anisopliae	100	USA (New York)	Lab.	Roberts (1970,1974)
Anopheles amictus hilli	Larvae	Culicinomyces sp.	High	Australia	Lab.	Sweeney (1975a), Sweeney et al. (1973)
Anopheles annulipes	Larvae	" "		Australia	Lab.	Sweeney (1975a)
Anopheles atroparvus atroparvus	Larvae	Smittium culicis[a]		France	Field	Manier (1969)
Anopheles claviger	Larvae	" "		France	Field	Manier (1969)
Anopheles coustani	Larvae	Trichophyton sp.				Dyé (1905)[b]
Anopheles freeborni	Larvae	Pythium sp. (near P. adhaerens)		USA (California)	Lab.	Clark et al. (1966)
Anopheles funestus	Larvae	Metarrhizium anisopliae	100	Nigeria	Field	Roberts (unpublished)
Anopheles gambiae	Larvae	"	100	Nigeria	Lab. & field	Roberts (unpublished)
Anopheles gambiae	Larvae	Smittium (= Rubetella) inopinata[a]	93-100	Italy	Lab.	Coluzzi (1966)

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Anopheles hispaniola	Larvae	Entomophthora culicis				López-Neyra & Guardiola Mira (1938)[b]
Anopheles maculipennis	Larvae	Beauveria bassiana			Lab.	Roubaud & Toumanoff (1930)[b]
" "	Larvae	Entomophthora culicis				López-Neyra & Guardiola Mira (1938)[b]
" "	Adults	Fungus				Léon (1924)[c]
" "	Larvae	Saprolegniaceae ?	100 (Lab.)	Yugoslavia	Lab. & field	Chorine & Baranoff (1929)[d]
" "	Adults	Yeast				Laveran (1902)[b]
Anopheles plumbeus	Larvae	Smittium culicis[a]		France	Field	Manier (1969)
" "	Larvae	" "		France	Lab.	Tuzet et al. (1961)
Anopheles punctipennis	Larvae	Culicinomyces clavosporus		USA (North Carolina)	Lab.	Couch et al. (1974)
" "	Larvae	Lagenidium giganteum		USA (North Carolina)	Lab.	Couch & Romney (1973)
Anopheles quadrimaculatus	Larvae	Beauveria bassiana				Charles (1939)[d]
" "	Larvae	Culicinomyces clavosporus		USA (North Carolina)	Lab.	Couch et al. (1974)
" "	Larvae	Lagenidium giganteum		USA (North Carolina)	Lab.	Couch & Romney (1973)
" "	Larvae	Metarrhizium anisopliae	100	USA (New York)	Lab.	Roberts (1970,1974)
" "	Larvae	Spicaria sp.				Brown (1949)[b]
Anopheles rufipes	Larvae	Metarrhizium anisopliae	100	Nigeria	Field	Roberts (unpublished)
Anopheles stephensi	Larvae	Culicinomyces clavosporus		USA (North Carolina)	Lab.	Couch et al. (1974)

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Anopheles stephensi	Larvae	Lagenidium giganteum		USA (North Carolina)	Lab.	Couch & Romney (1973)
" "	Larvae	Metarrhizium anisopliae	100	USA (New York)	Lab.	Roberts (1967,1970,1974)
Anopheles subpictus	Adults	Aspergillus parasiticus		India	Field	Hati & Ghosh (1965)
Armigeres dentatus	Eggs	Lagenidium sp.		Malaya	Field	Mattingly (1972a,b)
Culex sp.	Larvae	Aspergillus sp.				Speer (1927)[b]
" "	Larvae	Aspergillus glaucus			Lab.	Galli-Valerio & Rochaz de Jongh (1905)[d]
" "	Larvae	Aspergillus niger	High		Lab.	Galli-Valerio & Rochaz de Jongh (1905),[d] Speer (1927)[b]
" "	Larvae	Culicinomyces sp.		Australia	Lab.	Sweeney et al. (1973)
" "	Larvae, adults	Entomophthora conglomerata (= Empusa conglomerata, Empusa thaxteri)				Thaxter (1888)[d]
" "	Adults	Entomophthora culicis				Christophers (1952)[b]
" "		Entomophthora culicis		Poland USA (Maine)		Nowakowski (1883)[b] Thaxter (1888)[d]
" "	Larvae	Lagenidium giganteum	Low	USA (North Carolina)	Lab. & field	Couch (1935,1960)[d]
" "	Larvae	Oidium lactis	Low	USSR (Leningrad)	Lab.	Bačinskij (1926)[c]
" "	Larvae	Penicillium glaucum	Low	USSR (Leningrad)	Lab.	Bačinskij (1926)[c]
Culex apicalis	Larvae	Beauveria bassiana	100 (53% mortality in controls)	USSR (Byelorussia)	Lab.	Dyl'ko (1971)
Culex erraticus	Larvae	Culicinomyces clavosporus		USA (North Carolina)	Lab.	Couch et al. (1974)

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Culex exilis	Larvae	Beauveria bassiana	100 (53% mortality in controls)	USSR (Byelorussia)	Lab.	Dyl'ko (1971)
Culex gelidus	Adults	Aspergillus parasiticus		India	Field	Hati & Ghosh (1965)
Culex hortensis	Larvae	Smittium (= Orphella) culicis[a]		France	Field	Tuzet & Manier (1947)[d]
" "	Larvae	Smittium culicis[a]		France	Field	Manier (1969)
" "	Larvae	Smittium (= Rubetella) inopinata[a]	High	Italy	Field	Coluzzi (1966)
Culex modestus	Adults	Coelomycidium sp.	2	USSR (Uzbekistan)	Field	Shcherban' & Gol'berg (1971)
" "	Larvae	Smittium culicis[a]		France	Field	Manier (1969)
Culex nigripalpus	Larvae	Lagenidium giganteum (= L. culicidum)	100	USA (Georgia)	Lab.	McCray et al. (1973a), Umphlett (1973)
Culex pipiens	Larvae, adults	Beauveria bassiana (possibly Entomophthora culicis)				Dyé (1905)[b]
" "	Larvae	Beauveria bassiana	"Some"		Lab.	Roubaud & Toumanoff (1930)[b]
" "	Larvae, adults	" "	100 (70-95 in larval outdoor tests)	USA (California)	Lab., small scale outdoor tests against larvae	Clark et al. (1967,1968)
" "	Larvae	Beauveria tenella	100	USA (California)	Lab.	Pinnock et al. (1973), Sanders (1972)
" "	Adults	Cephalosporium, possibly C. coccorum	Considerable mortality	England	Field	Service (1969)

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Culex pipiens	Adults	Entomophthora?	High	Federal Republic of Germany	Field	Oda & Kuhlon (1973)
" "	Adults, pupae, larvae	Entomophthora sp.	95 (adults in field) 65-100 (♀, lab.) 33-67 (♂, lab.) 63-88 (pupae, lab.) 25 (larvae, lab.)	USSR (near Moscow)	Field & lab.	Gol'berg (1969,1970a, 1970b,1973)
" "	Adults	Entomophthora spp.	97	Netherlands	Field	Teernstra-Eeken & Engel (1967)
" "	Adults	Entomophthora conglomerata (= Empusa conglomerata, Empusa thaxteri				Brumpt (1941)[c] Lakon (1919)[d]
" "	Adults	Entomophthora conglomerata	63 (manholes) 47 (filtration fields) 2 (wooden barrels and wells 300 m from filtration fields) 30 (♀♀ on bank of water reservoir)	USSR	Field	Il'chenko (1968)

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Culex pipiens	Adults	Entomophthora conglomerata	16 (biting ♀♀ on bank of water reservoir) 0 (biting ♀♀ 700 m from water reservoir)	USSR	Field	Il'chenko (1968)
" "	Adults	Entomophthora conglomerata	40	USSR (near Moscow)	Field	Kupriyanova (1966a,b)
" "	Adults	Entomophthora conglomerata	95	USSR (near Moscow)	Field	Gol'berg (1969)
" "		Entomophthora culicis				Braun (1855),[d] López-Neyra & Guardiola Mira (1938),[b] Marshall (1938),[b] Speer (1927)[b]
" "	Adults	Entomophthora culicis	0-3	USSR	Lab.	Gol'berg (1973)
" "	Adults	Entomophthora destruens	0-10	USSR	Lab.	Gol'berg (1973)
" "	Adults	Entomophthora (Entomophaga) destruens	0-100	Czechoslovakia, England, France	Field	Novák (1965,1967,1971), Service (1969), Weiser & Batko (1966), Weiser & Novák (1964)
" "		Entomophthora henrici			Lab. Field	Brumpt (1941)[c] Molliard (1918)[d]
" "	Larvae	Smittium (= Rubetella) culicis[a]	100	France	Lab.	Tuzet et al. (1961)
" "	Larvae	Smittium (= Rubetella) inopinata[a]	93-100	Italy	Field & lab.	Coluzzi (1966)

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Culex pipiens fatigans (= C. pipiens quinquefasciatus	Larvae	Culicinomyces clavosporus		USA (North Carolina)	Lab.	Couch et al. (1974)
" "	Larvae	Lagenidium giganteum		USA (North Carolina)	Lab.	Couch & Romney (1973)
" "	Larvae	Lagenidium giganteum (= L. culicidum)	100	USA (Georgia)	Lab.	McCray et al. (1973a), Umphlett (1973)
" "	Adults	Conidiobolus coronatus (= Entomophthora coronata)	33 (lab.) (18% control mortality)	USA (Florida)	Lab.	Lowe & Kennel (1972)
" "	Adults	Conidiobolus coronatus (= Entomophthora coronata)		USA (Florida)	Field	Lowe et al. (1968)
" "	Larvae	Culicinomyces sp.		Australia	Lab.	Sweeney (1975a,b)
" "	Adults	Aspergillus parasiticus		India	Field & lab.	Hati & Ghosh (1965)
" "	Adults	Cladosporium ?	One specimen	Singapore	Lab.	Laird (1959)[d]
" "	Larvae	Metarrhizium anisopliae	100	Nigeria, France	Lab.	Roberts & Mouchet (unpublished)
" "	Larvae	Saprolegnia monica	Low	Australia	Lab.	Hamlyn-Harris (1932)[b]
C. pipiens pipiens	Adults	Coelomycidium sp.	3	USSR (Uzbekistan)	Field	Shcherban & Gol'berg (1971)
" " "	Larvae	Fusarium oxysporum	>80 (lab.)	France	Lab.	Hasan & Vago (1972)
" " "	Larvae	Metarrhizium anisopliae	100 (lab.) 94 (field)	USA (New York, Delaware)	Lab. & field	Roberts (1967,1970,1974)
" " "	Larvae	Smittium culicis		France	Field	Manier (1969)

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Culex restuans	Larvae	Culicinomyces clavosporus		USA (North Carolina)	Lab.	Couch et al. (1974)
" "	Larvae	Lagenidium giganteum	>95 (lab.) 100 (field)	USA (North Carolina)	Lab. & field	Umphlett & Huang (1972), Umphlett (1973)
" "	Larvae	Lagenidium giganteum		USA (North Carolina)	Lab.	Couch & Romney (1973)
" "	Larvae	Metarrhizium anisopliae	100	USA (New York)	Lab.	Roberts (1970,1974)
Culex tarsalis	Larvae, adults	Beauveria bassiana	100	USA (California)	Lab.	Clark et al. (1967,1968)
" "	Larvae	Beauveria tenellae	100	USA (California)	Lab.	Pinnock et al. (1973)
" "	Larvae	Lagenidium giganteum (= L. culicidum)	100	USA (North Carolina, Georgia)	Lab.	Couch & Romney (1973), McCray et al. (1973a), Umphlett (1973)
" "	Larvae	Lagenidium giganteum	8-100	USA (California)	Field	McCray et al. (1973b)
" "	Larvae	Pythium sp. (near P. adhaerens)			Lab.	Clark et al. (1966)
Culex territans	Larvae	Culicinomyces clavosporus		USA (North Carolina)	Lab.	Couch et al. (1974)
Culex theileri	Larvae	Amoebidium parasiticum[a]		Tunisia	Field	Manier et al. (1964)
" "	Larvae	Smittium (= Rubetella) culicis[a]		Tunisia	Field	
Culex tritaeniorhynchus summorosus	Larvae	Aspergillus sp.	High		Lab.	Laird (1959)[d]
Culiseta sp.	Larvae	Beauveria tenellae		USA (California)	Lab.	Sanders (1972)
Culiseta annulata	Larvae	Saprolegnia sp.				Marshall (1938)[b]
Culiseta (= Theobaldia) annulata	Larvae	Smittium culicis[a]		France	Field	Manier (1969)

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Culiseta impatiens	Larvae	Smittium culisetae[a]		USA (Colorado)	Field	Lichtwardt (1964), Williams & Lichtwardt (1972)
Culiseta incidens	Larvae	Beauveria tenellae	100	USA (California)	Lab.	Pinnock et al. (1973)
" "	Larvae	Lagenidium giganteum		USA (North Carolina)	Lab.	Couch & Romney (1973)
" "	Larvae	Pythium sp. (near P. adhaerens)		USA (California)	Lab.	Clark et al. (1966)
" "	Larvae	Smittium (= Rubetella) sp.[a]		USA (California)	Field	Clark et al. (1963)
" "	Larvae	Smittium culisetae[a]		USA (Colorado)	Field	Lichtwardt (1964)
Culiseta inornata	Larvae	Metarrhizium anisopliae	100	USA (New York)	Lab.	Roberts (1970,1974)
" "	Larvae	Pythium sp. (near P. adhaerens)		USA (California)	Lab.	Clark et al. (1966)
" "	Larvae	Smittium culisetae[a]		USA (Colorado)	Field	Lichtwardt (1964)
Culiseta longiareolata	Larvae	Smittium (= Rubetella) inopinata[a]	High	Italy	Field	Coluzzi (1966)
Culiseta melanura	Larvae	Culicinomyces clavosporus		USA (North Carolina)	Lab.	Couch et al. (1974)
Culiseta morsitans	Larvae	Entomophthora aquatica	10	USA (Connecticut)	Field	Anderson & Ringo (1969)
" "	Larvae	Saprolegnia sp.				Marshall (1938)[b]
Orthopodnyia californica	Larvae	Pythium sp. (near P. adhaerens)		USA (California)	Lab.	Clark et al. (1966)
Psorophora sp.	Larvae	Lagenidium giganteum	100	USA (North Carolina)	Field	Umphlett & Huang (1972), Umphlett (1973)
" "	Larvae	Polyscytalum				Howard, Dyar & Knab (1912)[b]
Psorophora confinnis	Larvae	Culicinomyces clavosporus		USA (North Carolina)	Lab.	Couch et al. (1974)

FUNGAL PATHOGENS, EXCEPT *COELOMOMYCES*, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Psorophora howardii	Eggs	*Polyscytalum* sp.				Martini (1920), Speer (1927)[b]
Psorophora lutzii		*Polyscytalum* sp.				Martini (1920)
Uranotaenia anhydor	Larvae	*Pythium* sp. (near *P. adhaerens*)		USA (California)	Lab.	Clark et al. (1966)
Uranotaenia sapphirina	Larvae	*Culicinomyces clavosporus*		USA (North Carolina)	Lab.	Couch et al. (1974)
Uranotaenia unguiculata	Larvae	*Smittium culicis*[a]		France	Field	Manier (1969)
Mosquitos		*Beauveria bassiana* (= *B. cinerea* from *theobaldiae*)				Morquer (1933)[b]
"		*Entomophthora gracilis*				Lakon (1919),[d] Picard (1914),[d] Thaxter (1888)[d]
"	Adults	*Entomophthora papilliata* (= *Lamia apiculata*)				Lakon (1919),[d] Marshall (1938)[b]
"	Adults	*Entomophthora rhizospora*	High		Field	Brumpt (1941),[c] Howard, Dyar & Knab (1912)[b]
"		*Entomophthora schroeteri* (= *E. rimosa*)				Brumpt (1941),[c] Schröter (1886)[b]
"		*Entomophthora sphaerosperma* (= *Tarichium sphaerospermum*, *Empusa radicans*, *Entomophthora radicans*, *Entomophthora phytonomi*)				Brumpt (1941),[c] Fresenius (1856),[d] Howard, Dyar & Knab (1912),[b] Thaxter (1888)[d]

FUNGAL PATHOGENS, EXCEPT COELOMOMYCES, OF CULICIDAE (MOSQUITOS) (continued)

Host	Host stage infected	Pathogen	% Incidence	Locality	Lab. or field study	Reference
Mosquitos		Entomophthora variabilis				Lakon (1919),[d] Thaxter (1888)[d]
"		Trichoderma viride				Steinhaus (1949)[d]
"	Larvae, adults	Trichophyton sp.?				Christophers (1952),[b] Liston (1901)[b]

ABSTRACTS

Mary Ann Strand & Donald W. Roberts

Anderson, J. F. & Ringo, S. L. (1969). Entomophthora aquatica sp. n. infecting larvae and pupae of floodwater mosquitoes. J. Invertebr. Pathol., 13: 386-393.

E. aquatica is a pathogen of larvae and pupae of Aedes canadensis and the larvae of Culiseta morsitans in woodland pools in Connecticut. No external changes are apparent in infected 4th instar larvae, although some changes in activity occur in larvae with extensive infections. Pupae killed by the fungus are identifiable by a white mat of conidiophores. Hyphal bodies are usually found in the parietal layer of the fat body, hemocoel, and nervous system.

Bačinskij, P. E. (1926). K biologii ličinok komarov anofeles i kuleks v svjazi s metodom biologičeskogo analiza Kol'kvica-Marssona i opytami zaraženija ličinok sporami plesnej. Gig. i Epidem., 5(4): 38-44. (Rev. appl. Ent. B, 15: 153.)

Braun, A. (1855). Algarum unicellularium genera nova et minus cognita, Leipzig, Engelmann, 111 pp.

Brown, E. S. (1949). Vorticellids (Protozoa: Ciliophora) epibiotic on larvae of the genus Aedes (Dipt., Culicidae). Ent. mth. Mag., 85: 31-34.

Brumpt, E. (1941). Les entomophthorées parasites des moustiques. Ann. Parasit. hum. comp., 18: 112-144. (Rev. appl. Ent. B, 30: 151.)

Chapman, H. C. et al. (1969). A two-year survey of pathogens and parasites of Culicidae, Chaoboridae, and Ceratopogonidae in Louisiana. Proc. N. J. Mosq. Exterm. Assoc., 56: 203-212.

Female adult Aedes sollicitans with many basidiomycete spores in their abdomens were found during the survey. They apparently acquire this fungus when feeding on exudates from Spartina spartinae plants. Identical fungal colonies have been isolated from the mosquitos and the exudate. The effect of this fungus on the mosquitos is not known.

Chapman, H. C. et al. (1967). Pathogens and parasites in Louisiana Culicidae and Chaoboridae. Proc. 54th Ann. Meet. N. J. Mosq. Exterm. Assoc. Atlantic City, March 15-17, pp. 54-60

Dissections of adult female mosquitos revealed 8.9 x 3.7 μ spores present as white opaque masses in their abdomens. Four mosquito species were involved, Aedes sollicitans, Culiseta inornata, Mansonia perturbans, and Psorophora confinnis. Incidence in Ae. sollicitans averaged 25% during one 2-month period. The identity of the fungus was unknown, but it is suspected to be a Basidiomycete. Its effect on the mosquito was unknown.

Charles, V. K. (1939). Notes on entomogenous fungi. Plant. Dis. Reptr., 23: 340. (Rev. appl. Ent. B, 28: 237.)

Chorine, V. & Baranoff, N. (1929). Sur deux champignons parasites d'Anopheles maculipennis Mg. C. R. Soc. Biol. (Paris), 101: 1025-1026. (Rev. appl. Ent. B, 17: 247.)

Christophers, S. R. (1952). The recorded parasites of mosquitos. Riv. Parassit., 13: 21-28.

Clark, T. B. et al. (1967). Experiments on the biological control of mosquitoes with the fungus Beauveria bassiana (Bals.) Vuill. Proc. Calif. Mosq. Control Assoc., 35: 99.

See Clark et al. (1968).

Clark, T. B. et al. (1968). Field and laboratory studies on the pathogenicity of the fungus Beauveria bassiana to three genera of mosquitoes. J. Invertebr. Pathol., 11: 1-7.

The susceptibility of Culex tarsalis, C. pipiens, Anopheles albimanus, Aedes aegypti, Ae. sierrensis, and Ae. nigromaculis to B. bassiana was tested. In field tests, conidial dust applied to the surface of the water was the most effective method for killing larvae. When applied at 3 lb./acre, 70-95% of the C. pipiens larvae died. Aedes spp. larvae were not susceptible in the field tests; however, adults of all species were susceptible in the laboratory. Eggs exposed to conidia hatched normally.

Clark, T. B. et al. (1963). Axenic culture of two trichomycetes from California mosquitoes. Nature, 197: 208-209.

Rubetella sp. and R. culicis were found inhabiting the rectum of mosquito larvae. Axenic culture was successfully accomplished using blood agar medium. Mosquitos were readily infected by exposing them to older cultures with conidia forming thalli.

Clark, T. B. et al. (1966). Pythium sp. (Phycomycetes: Phythiales) pathogenic to mosquito larvae. J. Invertebr. Pathol., 8: 351-354.

Motile zoospores of Pythium, the only infective stage, exhibited strongly positive chemotactic response to wounds of Aedes sierrensis larvae, but were apparently incapable of penetrating normal cuticle. Thus, wide variation of mortality rates in laboratory tests was a function of harshness of treatment and to zoospore concentration.

Coluzzi, M. (1966). Experimental infections with Rubetella fungi in Anopheles gambiae and other mosquitoes. Proc. 1st Int. Congr. Parasitol. (Rome), 1: 592-593.

Second instar larvae of laboratory colonies of Culex pipiens, Aedes aegypti, and Anopheles gambiae were exposed to 4th instar skins of larvae infected with Rubetella (inopinata?). Ninety-three to 100% of the prepupae became infected. No changes of vitality of C. pipiens and Ae. aegypti were observed. Twenty-seven per cent. (range = 12-87%) of the A. gambiae died. Death was the result of occlusion of the rectal ampulla.

Couch, J. N. (1935). A new saprophytic species of Lagenidium, with notes on other forms. Mycologia, 27: 376-387.

Couch, J. N. (1960). Some fungal parasites of mosquitoes. In [Proceedings of a conference on the] Biological control of insects of medical importance, Washington, D.C., American Institute of Biological Sciences, pp. 35-48.

Couch, J. N. & Romney, S. V. (1973). Sexual reproduction in Lagenidium giganteum. Mycologia, 65: 250-252.

The description of L. giganteum is emended in light of more complete knowledge of the life cycle. Nine strains of Lagenidium from the United States and India were examined and all were determined to be L. giganteum. Larvae of 11 mosquito species were susceptible to L. giganteum in the laboratory.

Couch, J. N. et al. (1974). New fungus which attacks mosquitoes and related Diptera. Mycologia, 66(2): 374-379.

Culicinomyces clavosporus, a new genus and species, is described from Anopheles quadrimaculatus. The infections were discovered in a laboratory colony reared with lake water from North Carolina. The fungus is culturable on a wide variety of artificial media. All larval stages are susceptible. Infection probably starts by the ingestion of conidia and death usually occurs within 60 hours after exposure. Infection experiments revealed the susceptibility of 10 other species of mosquitos.

Dyé, L. (1905). Les parasites des culicides. Arch. Parasit. (Paris), 9: 5-77.

Dyl'ko, M. I. (1971). Tests of the suitability of entobacterin and beauverin for the biological control of mosquito larvae. Minsk Belaruskaya Akad. Navuk Vesti Ser. Biyalagichnykh Navuk, 4: 85-89. (Bull. Acad. Sci. Byelorussian SSR, Biol. Sci. Ser., 4: 85-89.)

Dosages of 1.2 x 10^8 and 2.4 x 10^8 Beauveria bassiana conidia per ml totally prevented production of adults from Culex apicalis and C. exilis larvae.

Fresenius, G. (1856). Notiz, Insekten-Pilze betreffend. Bot. Ztg. 14: 882-883.

Galli-Valerio, B. & Rochaz de Jongh, J. (1905-6). Über die Wirkung von Aspergillus niger und A. glaucus auf die Larven von Culex und Anopheles. Zbl. Bakt., I. Abt. Orig., 38: 174-177; 40: 630.

Gol'berg, A. M. (1969). The finding of entomophthoraceous fungi on mosquitoes (Family Culicidae) and midges (Family Ceratopogonidae). Med. Parazitol. Parazit. Bolezni, 38(1): 21-23. (R, e).

Entomophthora conglomerata and an unnamed Entomophthora sp. were found infecting Culex pipiens pipiens adults in filtration fields near Moscow. The maximum infection rate was 95% and it occurred in late July-early August.

Gol'berg, A. M. (1970a). [Experimental infection of mosquitoes of the family Culicidae with Entomophthora. Communication I. Species specificity of the fungus Entomophthora sp.] Med. Parazitol. Parazit. Bolezni, 39(4): 472-478.

Culex pipiens adults were frequently found infected by Entomophthora near Moscow. Experimental infection of the mosquitos was successful. After testing a number of mosquito species, including Aedes dorsalis, A. aegypti, Anopheles maculipennis messiae, A. m. atroparvus, the Entomophthora proved to be specific for Culex pipiens.

Gol'berg, A. M. (1970b). Experimental infection of mosquitoes of the family Culicidae with Entomophthora. Communication II. Susceptibility to entomophthorosis of preimaginal stages and adults Culex pipiens L. mosquitoes. Med. Parazitol. Parazit. Bolezni, 39(6): 694-698.

Conidia of Entomophthora sp. were used to experimentally infect Culex pipiens. Insects dying of entomophthorosis were capable of infecting healthy mosquitos for 6-7 days from onset of conidia elimination. Adults were found to be most susceptible with females dying more frequently (64.6-100%) than males (33.3-66.6%). Pupae (63.0-88.4%) and fourth instar larvae (24.6%) were also susceptible; however, younger instars could not be infected. From the artificially infected mosquitos, all stages of the fungus were obtained: hyphal bodies, conidia, and dormant spores.

Gol'berg, A. M. (1973). Experimental infestation of mosquitoes of the family Culicidae with Entomophthora. III. Use of fungal cultures of the Entomophthoraceae family. Med. Parazitol. Parazit. Bolezni, 42(5): 616-618.

Culex pipiens molestus was experimentally exposed to cultures of Entomophthora sp., E. culis, and E. destruens. These cultures caused less than 10% adult mortality and did not adversely affect larval development, even though a previous study (Gol'berg, 1970b) established that Entomophthora sp. conidia from cadavers were infective.

Hamlyn-Harris, R. (1932). Some further observations on Chara fragilis in relation to mosquito breeding in Queensland. Ann trop. Med. Parasit., 26: 519-524. (Rev. appl. Ent. B, 21: 52.)

Hasan, S. & Vago, C. (1972). The pathogenicity of Fusarium oxysporum to mosquito larvae. J. Invertebr. Pathol., 20: 268-271.

Aedes detritus larvae naturally infected with F. oxysporum were collected from marshy areas in southern France. In the laboratory, A. detritus and Culex pipiens pipiens larvae were infected by conidia obtained from cultures and diseased bodies. More than 80% died, and injured or young larvae were the most susceptible. Spores germinated in the intestinal lumen and the mycelium invaded all tissues.

Hati, A. K. & Ghosh, S. M. (1965). Aspergillus parasiticus infection in adult mosquitoes. Bull. Calcutta Sch. Trop. Med., 13(1): 18-19.

Growth of a fungus was noticed from thorax to abdomen of 3 species of adult mosquitos (Culex gelidus, C. fatigans, and Anopheles subpictus) collected near Calcutta. From cultures, the fungus was identified and subcultures were used to infect C. fatigans. The symptoms produced were similar to those of the naturally infected mosquitos.

Howard, L. O. et al. (1912). The mosquitoes of North and Central America and the West Indies. Washington, Carnegie Inst., 1: 156-179.

Il'chenko, L. Ya. (1968). The infection of the mosquito Culex pipiens L. with the parasitic fungus Entomophthora conglomerata Sorok in the vicinity of Novocherkassk. Med. Parazitol. Parazit. Bolezni, 37: 613-615. (In Russian, Eng. sum.)

Adults and pupa C. pipiens were found infected with E. conglomerata from June to end of September in filtration fields, and other places with standing water. Although 15.6% of the females attacking near a reservoir were infected, no infected specimens were found in a village 700-8000 m away.

Jettmar, H. M. von. (1947). Mikrobien als Feinde von Stechmückenlarven. Acta trop. (Basel), 4: 193-209.

Kuno, G. (1973). Biological notes of Amoebidium parasiticum found in Puerto Rico. J. Invertebr. Pathol., 21: 1-8.

Under optimum rearing conditions, A. parasiticum does not cause mortality of Aedes aegypti larvae. However if starved, the mortality rate of infected larvae was significantly greater than the controls.

Kupriyanova, E. S. (1966a). Entomophthora fungus parasitizing mosquitoes of the Culex pipiens L. complex. Zool. Zhur., 45(5): 675-678. (Russian, Eng. sum.)

C. pipiens, breeding in filter beds of a sewage disposal system near Moscow, were found to be infected by E. conglomerata. The fungus infects mosquitos in adult stage or at the moment of eclosion from pupae. Healthy adults may become infected when they visit water bodies for oviposition.

Kupriyanova, E. S. (1966b). Parasitization of mosquitoes of the Culex pipiens L. complex by fungi of the order Entomophthorales. Unpublished World Health Organization document WHO/EBL/66.57, 10 pp.

An epizootic caused by Entomophthora conglomerata was found in a population of C. pipiens along the edges of sewage filter beds near Moscow. About 40% of the recently emerged adults were infected. Infections were not observed beyond the immediate vicinity of the larval habitat.

Laird, M. (1959b). Parasites of Singapore mosquitoes, with particular reference to the significance of larval epibionts as an index of habitat pollution. Ecology, 40: 206-221.

Lakon, G. (1919). Die Insektenfeinde aus der Famílie der Entomophthoreen. Beiträge zu einer Monographie der insektentötenden Pilze. Z. angew. Ent., 5: 161-216.

Laveran, A. (1902). De quelques parasites des culicides. C. R. Soc. Biol. (Paris), 54: 233-235.

Léon, N. (1924). Action des ectoparasites sur les culicides. Ann. Parasit. hum. comp. 2: 211-213. (Rev. appl. Ent. B, 12: 143.)

Lichtwardt, R. W. (1964). Axenic culture of two species of branched Trichomycetes. Am. J. Bot., 51: 836-842.

Smittium culisetae was isolated from hind-guts of Culiseta impatiens larvae. It was grown on 10% brain-heart infusion.

Liston, W. G. (1901). A year's experience of the habits of Anopheles in Ellickpur. Indian med. Gaz., 36: 361-366, 441-443.

López-Neyra, C. A. & Guardiola Mira, A. (1938). Protofitos parásitos de los mosquitos y sus larvas en España. Bol. Univ. Granada, 10: 105-114. (Rev. appl. Ent. B, 27: 96.)

Lowe, R. E. & Kennel, E. W. (1972). Pathogenicity of the fungus Entomophthora coronata in Culex pipiens quinquefasciatus and Aedes taeniorhynchus. Mosq. News, 32(4): 614-620.

Third instar larvae of C. p. quinquefasciatus were not susceptible to the fungus; however, it did grow in one 3rd instar A. taeniorhynchus. Pupae and adults of both species were also susceptible. Histological examination revealed the penetration of the insect cuticle by the fungal germ tubes. The fungus was detected in the connective tissue of an experimentally infected white mouse.

Lowe, R. E. et al. (1968). Entomophthora coronata as a pathogen of mosquitoes. J. Invertebr. Pathol., 11: 506-507.

Infected adult Culex pipiens quinquefasciatus mosquitos were found in a laboratory colony in Florida. One of the first signs of abnormality was a drastic reduction in egg production. Histopathological examinations revealed that the fungus had invaded all parts of the infected bodies.

Macfie, J. W. S. (1917). Fungal infections of mosquito larvae. Rep. Accra Lab. (1916), 76-80. (Rev. appl. Ent. B, 6: 16.)

Manier, J.-F. (1969). Trichomycetes de France. Ann. Sci. Nat. Bot. Biol. Veg. Ser., 12, 10(4): 565-672.

A list of insect hosts and Trichomycetes species is given. Thirteen species of mosquitos were listed as hosts, infected mainly by Smittium culicis.

Manier, J.-F. et al. (1964). Presence en Tunisie de deux Trichomycetes parasites de larves de Culicides. Arch. Inst. Pasteur Tunis, 41: 147-152.

Amoebidium parasiticum was observed on the larvae of Aedes detritus and Culex theileri. Smittium (= Rubetella) culicis was also found on C. theileri. Descriptions of the two fungi are given.

Marchoux, E. et al. (1903). La fièvre jaune. Rapport de la mission française. Ann. Inst. Pasteur, 17: 665-731.

Marshall, J. F. (1938). The British mosquitoes. London, British Museum (Nat. Hist.), 341 pp.

Martini, E. (1920). Über Stechmücken besonders deren europäische Arten und ihre Bekämpfung. Arch. Schiffs-u. Tropenhyg., 24: 1-267.

Mattingly, P. F. (1972a). Mosquito eggs. XVII. Further notes on egg parasitization in genus Armigeres. Mosq. Syst., 4: 1-8.

Speculations as to the identity of parasites on the eggs of A. dentatus are made. (See Mattingly, 1972b.)

Mattingly, P. F. (1972b). Mosquito eggs. XX. Egg parasitism in Anopheles with further notes on Armigeres. Mosq. Syst., 4: 84-86.

The egg parasite previously described by this author has been recognized as a Lagenidiales, probably Lagenidium sp.

McCray, E. M., jr (1973a). Laboratory studies on a new fungal pathogen of mosquitoes. Mosq. News, 33(1): 54-60.

Motile zoospores of Lagenidium giganteum (see Umphlett, 1973) are normally ingested and probably enter the tissues of the mosquito larvae through the anterior portion of the digestive tract. Sporangial formation and larval death are usually simultaneous, occurring about 60 hours after infection. Larvae of several species of Aedes and Culex were susceptible but none of the Anopheles were. There was no loss of infectivity after passage through different host species. Younger larvae were more susceptible than older ones and no infected adults were found.

McCray, E. M. et al. (1973b). Laboratory observations and field tests with Lagenidium against California mosquitoes. Proc. and Papers of 41st Ann. Conf. Calif. Mosq. Control Assoc., p. 123-128.

Laboratory observations of the life cycle of L. giganteum revealed two modes of action. In a permanent body of water, the fungus produces asexual zoospores which are released from the infected larvae to infect other larvae and the cycle is repeated. In intermittently dry and flooded areas, the fungus goes through a sexual cycle and produces resting oospores which germinate when rewetted. Field tests in both types of locations resulted in dramatically reduced mosquito populations. No infections were found in 1400 other aquatic organisms from the treated sites.

Molliard, M. (1918). Sur la vie saprophytique d'une Entomophthora (E. Henrici n. sp.). C. R. Acad. Sci. (Paris), 167: 958-960.

Morquer, R. (1933). Considérations biologiques sur les variations du Botrytis cinerea et spécialement sur une nouvelle forme (forma theobaldiae) pathogène pour les Culicides. Bull. Soc. Hist. nat. Toulouse, 65: 603-617. (Rev. appl. Ent. B, 22: 119.)

Novák, D. (1965). Zum Auftreten der Mykosen bei Stechmücken in Mähren (Diptera: Culicidae). Beitr. Entomol., 15: 135-137. (G, e)

Adults of Culex pipiens infected by Entomophthora conglomerata (see Weiser and Batko, 1966) were collected in Czechoslovakia. The infected mosquitos occurred in damp cellars or similar places in southern Moravia. Infections occurred yearly in the same places but spread little. The mosquitos entered the cellars in the fall and nearly all died during the winter. C. annulata were not infected.

Novák, D. (1967). Beobachtungen zur Verbreitung von Mykosen bei Stechmücken. Zeitschrift für Tropenmedizin und Parasitologie, 18: 488-491.

Mortality of overwintering Culex pipiens pipiens adults due to Entomophthora destruens was observed at irregular intervals for 6 years at two sites. Temperatures ranged from 1 to 20°C and relative humidities from 45 to 100%. Infected specimens were collected during all seasons of the year. Infection levels, in most cases, were 50% or greater. Dead mosquitos were found on brick, wood, rubber, and iron substrates. Spores survived 6-7 months in cool, damp, humid environments. Heat, dryness, and fresh paint destroyed the fungus.

Novák, D. (1971). Weiterer Beobactungen zur Verbreitung von Mykosen bei Stechmücken von Culex pipiens. Biologia (Bratisl.), 28(8): 643-645. (G, e, p)

In two cellars in which mosquitos regularly overwintered, many were found to be infected by Entomophthora destruens (see Weiser & Batko, 1966). Mortality due to this fungus was greatest in the autumn months when as many as 85% died.

Nowakowski, L. (1883). Entomophthorae, przyczynek do znajomści pasożytnych grzbków, sprawiajacych pomór owadów. Pam. Akad. Umiejet. Krakow., Wydz. mat.-nat., 8: 153-183.

Oda, T. & Kuhlow, F. (1973). Beobactungen über Sterblichkeit und Follikelgrösse bei Culex pipiens pipiens L. im Verlauf der Überwinterung. Z. Tropenmed. Parasitol., 24: 373-378.

A high mortality rate from an unidentified fungus was observed in female mosquitos overwintering in cellars. Many of the dead were covered with mould.

Picard, F. (1914). Les Entomophthorées, leur parasitisme chez les insectes. Bull. Soc. Zool. agric., 13: 1-7, 25-30, 37-40, 62-65.

Pinnock, D. E. et al. (1973). Beauveria tenella as a control agent for mosquito larvae. J. Invertebr. Pathol., 22: 143-147.

B. brongniartii (= tenella) was isolated from naturally infected Aedes sierrensis mosquitos captured in California. Other species of Aedes, Culex, and Culiseta were also susceptible in laboratory tests. The mortality rate of A. sierrensis was not correlated to inoculation concentration, but correlations were observed in tests with other species. Mortality percentage was influenced by incubation temperature and early instars were the most susceptible stages. In field trials, significant reductions of emerging A. sierrensis adults (53-71% over controls) were observed in treated tree holes.

Rioux, J. A. & Achard, F. (1956). Entomophytose mortelle à Saprolegnia diclina Humphrey 1892 dans un élevage d'Aedes berlandi Seguy 1921. Vie et Milieu, 7: 326-337.

Roberts, D. W. (1967). Some effects of Metarrhizium anisopliae and its toxins on mosquito larvae. In Insect Pathology and Microbial Control (van der Laan, P. A., ed.) pp. 243-246. North-Holland Publ. Co., Amsterdam.

Exposure to viable M. anisopliae conidia was fatal to several species of mosquitos. The fungus mycelium produces destruxins A and B in vitro. These compounds are also toxic to mosquito larvae.

Roberts, D. W. (1970). Coelomomyces, Entomophthora, Beauveria, and Metarrhizium as parasites of mosquitoes. Misc. Publ. Entomol. Soc. Am., 7(1): 140-155.

The use of fungi for mosquito control is discussed. Natural infections of Entomophthora occur in both larvae and adults and observations indicate that significant control can be achieved. Beauveria and Metarrhizium are not normally associated with mosquitos, so require repeated applications for use in control.

Roberts, D. W. (1974). Fungal infections of mosquitoes, p. 143-193. In Aubin, A. et al. (ed.), Le contrôle des moustiques/Mosquito control. Univ. Quebec Press, Quebec.

In this review paper, the host range, distribution, life cycle, and possibility as microbial control agents were discussed for fungal parasites, including Lagenidium, Entomophthora, Beauveria, and Metarrhizium.

Roubaud, E. & Toumanoff, C. (1930). Essais d'infection expérimentale de larves de culicides par quelques champignons entomophytes. Bull. Soc. Path. exot., 23: 1025-1027.

Sanders, R. D. (1972). Microbial mortality factors in Aedes sierrensis populations. Proc. Calif. Mosq. Control Assoc., 40: 66-68

Mosquitos infected with Beauveria brongniartii (= tenella) were found in 4 of 18 tree holes examined near Novato, California. Twenty-six to 91% of the larvae were infected.

Schröter, J. (1889). Pilze. In Cohn, F., ed., Kryptogamen-flora von Schlesien, Breslau, Kern, 3: 217

Service, M. W. (1969). Observations on the ecology of some British mosquitoes. Bull Entomol. Res., 59: 161-194.

Overwintering Culex pipiens adults were infected by Cephalosporium sp. (possibly C. coccorum) and Entomophthora sp. near conglomerata. Mortality levels exceeded 50% in November and December. Infection was virtually non-existent in populations resting on ceilings, which were drier than walls. In 11 overwintering sites, infection occurred only in those with damp walls.

Shcherban', Z. P. & Gol'berg, A. M. (1971). The pathogenic fungi Coelomycidium (Phycomycetes, Chytridiales) and Coelomomyces (Phycomycetes, Blastocladiales) in Culex and Aedes (Diptera, Culicidae) in Uzbekistan. Med. Parazitol. Parazit. Bolezni., 40(1): 110-111.

Coelomycidium sp. infected 2.4% of Culex modestus and 3.4% of C. pipiens pipiens mosquitos collected in the Fergana valley. In the laboratory infected females died within one week of taking a blood meal.

Sorokin, N. (1877). Über zwei neue Entomophthora-Arten. Beitr. Biol. Pflanzen, 2: 387-398.

Speer, A. J (1927). Compendium of the parasites of mosquitoes (Culicidae). Hyg. Lab. Bull. (Wash.), 146: 1-36.

Steinhaus, E. A. (1949b). Principles of insect pathology. New York, McGraw-Hill, 757 pp.

Sweeney, A. W. (1975a). The insect pathogenic fungus Culicinomyces in mosquitoes and other hosts. Australian Jour. Zool., 23: 59-64.

The host range of an Australian Culicinomyces sp. was examined by testing against aquatic insects, shrimp, and fish. Larval Culicidae (Anopheles annulipes, An. amictus hilli, Aedes australis and Culex pipiens fatigans), Chironomidae (Chironomus sp.), and Ceratopogonidae (Dasyhelea and Bezzia) were susceptible. Another dipteran, Psychodidae (Telmatoscopus albipunctatus) was not susceptible. Caddis-fly larvae (Trichoptera), dragonfly naiads (Zygoptera and Anisoptera), freshwater shrimp (Atyidae), and Gambusia fish were all nonsusceptible.

Sweeney, A. W. (1975b). The mode of infection of the insect pathogenic fungus Culicinomyces in larvae of the mosquito Culex fatigans. Australian Jour. Zool., 23: 49-57.

The initiation and development of infection by an Australian Culicinomyces sp. in Culex pipiens fatigans larvae was followed by dissection and by histology. The infection sites were the foregut and hindgut, and not the exterior integument. After death conidia were produced on the external surface of the cadaver by conidiophores which penetrated from the hemocoel.

Sweeney, A. W. et al. (1973). A fungal pathogen for mosquito larvae with potential as a microbial insecticide. Search, 4(8): 344-345. (WHO/VBC/73.444, WHO/MAL/73.805.)

A fungal parasite was isolated from Anopheles amictus hilli. It appears to be a new pathogen of aquatic Diptera, but it resembles the common terrestrial insect pathogenic fungus Metarrhizium anisopliae. Mosquito larvae of three genera (Anopheles, Culex, and Aedes) are susceptible to infection. Infection by ingestion is effective against mosquito larvae which feed non-selectively. Prolonged subculturing did not lead to loss of pathogenicity.

Sweeney, A. W. & Panter, C. (1974). The pathogenicity of the fungus Culicinomyces to mosquito larvae in a natural field habitat. Unpublished World Health Organization document WHO/VBC/74.470, 2 pp.

Spores of Culicinomyces sp. from Australia were introduced into two rock pools (6 and 40 litres, 10^6 and 10^5 spores/ml, respectively), which contained naturally occurring populations of Aedes rupestris. Infected larvae were collected daily for 6 days, at which time the pools were flushed by heavy rain. The percentage of larvae infected was not determined, but the experiment established that infection could occur in a natural mosquito habitat as well as in the laboratory.

Teernstra-Eeken, M. H. & Engel, A. (1967). Notes on entomophthorous fungi on Heleomyzidae and Culicidae (Diptera). J. Invertebr. Pathol., 9, 431-432.

Entomophthora spp. were found parasitizing a population of Culex pipiens which was overwintering in caves in the Netherlands. By the beginning of February 92-97% of the population was dead.

Thaxter, R. (1888). The Entomophthoreae of the United States. Mem. Boston Soc. nat. Hist., 4: 133-201.

Tuzet, O. & Manier, J. F. (1947). Orphella culici n. sp., entophyte parasite du rectum des larves de Culex hortensis Fclb. C. R. Acad. Sci. (Paris), 225: 264-265.

Tuzet, O. et al. (1961). Rubetella culicis (Tuzet et Manier, 1947), trichomycète rameux, parasite de l'ampoule rectale des larves de culicides (morphologie et spécificité). Viet et Milieu, 12: 167-187.

Umphlett, C. J. (1973). A note to identify certain isolate of Lagenidium which kills mosquito larvae. Mycologia, 65(4): 970-972.

The synonomy of L. giganteum and L. culicidum is demonstrated. The name is properly L. giganteum.

Umphlett, C. J. & Huang, C. S. (1972). Experimental infection of mosquito larvae by a species of the aquatic fungus Lagenidium. J. Invertebr. Pathol., 20: 326-331.

The susceptibility of Culex restuans to L. giganteum (Umphlett, 1973) was tested. At low dosages, younger larvae were most susceptible, but over 80% of the larvae of all ages died at high dosages.

Umphlett, C. J. & McCray, E. M. jr (1975). A brief review of the involvements of Lagenidium, an aquatic fungus parasite, with arthropods. Marine Fisheries Review, 37: 61-64.

Several species of Lagenidium have been reported as parasites of arthropods including mosquitos. L. giganteum has been shown to be a virulent pathogen of several species of mosquitos. However, more than 1400 acquatic non-target organisms (small crustaceans and insects) from sites where L. giganteum had been introduced were found not to be infected. It has also been shown not to be pathogenic to small mammals.

Weiser, J. & Batko, A. (1966). A new parasite of Culex pipiens L. Entomophthora destruens sp. nov. (Phycomycetes, Entomophthoraceae). Folia Parasitol. (Praha), 13(2): 144-149.

A fungus previously reported to cause heavy mortality in some localities among hibernating adult mosquitos in Czechoslovakia is described. It can be cultured on egg-yolk medium. (See Novak, 1965, and Weiser & Novak, 1964.)

Weiser, J. & Novak, D. (1964). Auftreten vom Mykosen bei Stechmücken. Entomophaga Mem. Hors Ser., 2: 149-150.

A fungus infection caused by Entomophthora destruens (Weiser & Batko, 1966) is common in overwintering populations of Culex pipiens in Czechoslovakia. More than 50% of natural shelters and basements are infected and a steadily increasing infection occurs in the hibernating population. Although present in the shelters, Culiseta Theobaldia sp. mosquitos are not infected.

Williams, M. C. & Lichtwardt, R. A. (1972). Infection of Aedes aegypti larvae by axenic cultures of the fungal genus Smittium (Trichomycetes). Am. J. Bot., 59: 189-193

Spores produced by cultures isolated from various locations and dipteran hosts were fed to the mosquito larvae. Some host but no geographical specificity was found. This fungus apparently has little effect on larvae reared under optimum conditions.