

On the subgenera of the fungus genus *Zoophthora* Batko 1964 (*Entomophthoraceae*)

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The genus *Zoophthora* Batko (1964 a) is a relatively extensive widely differentiated taxonomic group. At present this genus is composed of the species described up to 1964 as belonging to the genera *Empusa* Cohn, *Entomophthora* Fresenius non Nowakowski and *Entomophthora* auct. non Fresenius sensu Nowakowski (Batko 1964 b). There are in all about 35 species the type species *Zoophthora radicans* (Brefeld) Batko (1964 a) included. Moreover two new species of *Zoophthora* have been recently described: *Z. vomitoriae* Rozsypal (1966) and *Z. phalloides* Batko (1966).

The intrageneric differentiation of the *Zoophthora* species is, in spite of the distinct relationships between them, quite pronounced. All the species have characteristic uninucleate conidia with a double membrane and ramified conidiophores, and they exhibit the ability of fixing the host's body on the substrate by means of rhizoids. The primary conidia of *Z. radicans*, and related species, however, differ from those of *Z. aphidis* and related fungi by their shape and the tendency of its variation as well as by the plasma structure and nucleus shape. The same may be said of the rhizoids which in some species are thread like, unbranched and gathered in bundles, and in others massive, frequently ramified, ending in a large „foot” often of complex structure. Also the structure of the pseudocystides in various *Zoophthora* species is varied: in some they are distended and have shapes specific to the given species, in others they are thin and their structure is nonspecific or else they are absent.

The last distinctive trait of the *Zoophthora* species is the structure of secondary conidia. In most species they are of the same shape and type (according to Lakon's classification, 1919) as the primary ones, but in *Z. radicans*, *Z. phalloides* and *Z. occidentalis* anadhesisporous (lemonshaped dry conidia) formed on capillary secondary conidiophores have been found. The ability of forming anadhesisporous indicates a relationships of this group of *Zoophthora* species to the genus *Triplo-*

sporium (Thaxter) Batko (1964 a) and to some species of the genus *Conidiobolus* Brefeld (1884) mostly described by Drechsler and not quoted here.

All the above named traits specific to the particular groups of *Zoophthora* species are distinctly correlated. For instance the formation of anadhesisporae is typical of species with thread-like rhizoids aggregated in pseudorhizomorphs, and enlarged pseudocystides of complex structure occur always with single thick rhizoids, however deprived of a distinctly shaped „foot”. After separating on this basis the genus *Zoophthora* into four subgenera, the author established that three of them consist of species parasitizing on members of the four basic groups of insects being hosts of entomophthoraceous fungi: *Homoptera*, *Coleoptera*, *Diptera* and *Lepidoptera*. On insects of each of the enumerated orders so far at least one species of each of three basic subgenera of *Zoophthora* was found. This seems to suggest that the subgenera proposed are in a large extent „natural” and objectively correspond to the existing groups of species formed by way of adaptation to parasitism on insects from three related ancestral species. This has convinced the author of the usefulness of distinguishing several subgenera within the genus *Zoophthora*. In this connection the following names and diagnoses are proposed:

Zoophthora subg. *Zoophthora*

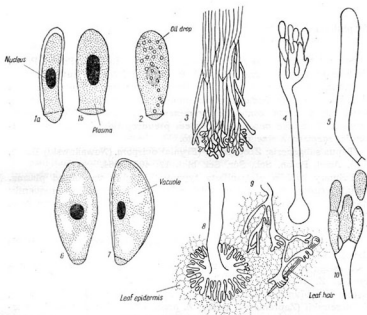
(Figs 1—3)

Conidia primaria oblongata, cylindrica, oblonge ovata vel fusiformia, plasmate homogenica hyalinaquae, ordinarie deficientibus vacuolis vel granulis. Nucleus oblongatus, in conidiis non coloratis saepe videri potest. Secundum Lakoni (1919) classificatione conidia ad typos papillata et turbinata pertinent. Conidia secundaria primariis similia vel anadhaesisporae sunt. Pseudocystidia tenua, conidiophoris non maceriores, vel omnine desunt. Rhizoidea tenua, fufiformia, inramosa, terminis non dilatatis, in pseudorhizomorphas congregata.

Typus subgeneris: *Zoophthora (Zoophthora) radicans* (Brefeld) Batko, Bull. Acad. Polon. Sci., Sér. sci. biol. 12: 320. 1964.

Primary conidia elongated: cylindrical, oval or fusiform, with homogenous hyaline plasma generally without large vacuoles or robust granules; nucleus elongated frequently visible in unstained spores, stains much more intensively with cotton blue in lactophenol than plasma, according to Lakoni's (1919) classification the conidia belong to the typos papillata or turbinata. Secondary conidia similar to primary ones or anadhesisporae. Pseudocystides thin, not thicker than conidiophores or absent. Rhizoids thin, threadlike, unbranched, not widened at ends, aggregated in pseudorhizomorphs.

Plate I



Figs 1—10. Morphology of *Zoophthora* spp. 1, 2 — conidia of subgenus *Zoophthora* members; 3 — cluster of rhizoids of *Zoophthora* subg. *Zoophthora* sp.; 4, 5 — conidiophore and pseudocystistide of subgenus *Erynia* member; 6 — conidium of *Zoophthora* subg. *Pandora* sp., dorsal view; 7 — as 6, lateral view; 8—9 — foots of *Pandora* sp. rhizoids; 10 — conidiophore and conidium of *Zoophthora* (*Furia*) *virescens* (all figures semidiagrammatic, fig. 10 redrawn from Thaxter, 1888 and simplified).

Type of subgenus: *Zoophthora* (*Zoophthora*) *radicans* (Brefeld) Batko (1964 a).

Besides *Z. radicans* I assign to the subgenus *Zoophthora* the species: *Z. americana* (Thaxter) Batko, *Z. creatonotus* (Yen) Batko, *Z. forficulae* (Giard) Batko, *Z. geometralis* (Thaxter) Batko, *Z. occidentalis* (Thaxter) Batko, *Z. phytonomi* (Arthur) Batko (Batko 1964 c), *Z. phalloides* Batko (1966), *Z. bullata* (Thaxter in Povah) comb. nov. (Basonym: *Empusa* (*Entomophthora*) *bullata* Thaxter in Povah, Pap. Michigan Acad. Sci. 20: 113—156. 1935), and *Z. nebriae* (Raunkiaer) comb. nov. (Basonym: *Entomophthora nebriae* Raunkiaer, Botan. Tidsskr. 18: 108—111. 1892).

Zoophthora subg. *Erynia* (Nowakowski) subg. nov.

(Figs 4 and 5)

Syn.: *Erynia* Nowakowski, Dziennik III Zjazdu Lek. Przyr. Polsk. Kraków 6: 67, 1881 (name invalid as rejected later by author).

Conidia primaria ad typos papillata pertinentia, plasmate vacuolis abundanter pedita. Pseudocystidia conidiophoris multipliciter maceriora, saepe supra strata conidialia prominentia et modo valde complexe formata. Rhizoidea quoad maceritatem pseudocystidiis similia vel recentia, saepissime sine pede distincto.

Typus subgeneris: *Zoophthora* (*Erynia*) *ovispora* (Nowakowski) Batko, Bull. Acad. Polon. Sci., Sér. Sci. biol. 12: 405, 1964.

Primary conidia of papillata type with highly vacuolized plasma. Pseudocystides many times thicker than conidiophores, frequently standing out high above the sporiferous layer and of complex structure. Rhizoids as thick as pseudocystides or thinner, generally without distinct foot.

Type of subgenus: *Zoophthora* (*Erynia*) *ovispora* (Nowakowski) Batko (1964 c).

I assign to the subgenus *Erynia*, beside *Z. ovispora* the following species: *Z. curvispora* (Nowakowski) Batko, *Z. conica* (Nowakowski) Batko, *Z. blunckii* (Lakon) Batko, *Z. rhizospora* (Thaxter) Batko, *Z. jaczewskii* (Zaprometov) Batko, *Z. gracilis* (Thaxter) Batko, *Z. variabilis* (Thaxter) Batko, *Z. montana* (Thaxter) Batko and *Z. sepúlchralis* (Thaxter) Batko (Batko 1964 c).

Zoophthora subg. *Pandora* subg. nov.

(Figs 6—9)

Conidia cylindrica, ovulata, adverse ovulata, pyriformia, rarius — fusi-formia, in classificatione Lakonii (1919) ad typos subpapillata, rarius

papillata vel sporangiata pertinentia, saepe symetria laterali vix respecta distincta. Una ex parte (ventrali) leviter complanata, altera ex parte (dorsali) magis ventriosa, tertia ex parte (lateralis) leviter ad partem ventralem curvata, et paululum asymetrica. Papilla parti ventrali proximior. Plasma multis cum vacuolis, squamosa et granulosa, saepe cum cristallico corpore lucem fortiter fractantem, non longe a basi posita. Nucleus sphaericus vel lensiformis saepe ventrali superficiei conidii proximior, aliquando irregularis. Pseudocystidia tenua, conidiophoris non maceriores, vel omnino desunt. Rhizoidea singularia, macria, terminata lato scutalique pede, aliquando irregulariter ramosa; termini ramorum in brevium processorum fasciculos congregati.

Typus subgeneris: *Zoophthora* (*Pandora*) *aphidis* (Hoffman in Fresenius) Batko, Bull. Acad. Polon. Sci., Sér., sci. biol. 12: 405. 1964.

Conidia oval, ovoid, obovoid, pyriform, less frequently fusiform, according to Lakon's classification (1919) of subpapillata type, less frequently papillata or sporangiata, often with weakly outlined bilateral symmetry: on one side (abdominal) slightly flattened, on opposite (dorsal) side more convex, on the third (lateral) side somewhat curved towards the abdominal side and slightly asymmetrical, papilla nearer abdominal side: plasma highly vacuolated, foamy or granulated, sometimes contains large highly refractive crystals near base of conidium; nucleus spherical or slightly depressed, frequently closer to abdominal surface of conidium, sometimes slightly irregular, stains only a little more intensively with cotton blue than the plasma. Pseudocystidia thin, not thicker than conidiophores or absent. Rhizoids single, thick or thin, ending in broad scutellar or irregular foot, sometimes irregularly branched. The ends of the ramifications have the form of bunches of short processes.

Type of subgenus: *Zoophthora* (*Pandora*) *aphidis* (Hoffman in Fresenius) Batko (1964 c).

To the subgenus *Pandora* I assign, beside *Z. aphidis*, the following species: *Z. brahminae* (Bose et Mehta) Batko, *Z. calliphorae* (Giard) Batko, *Z. dipterigena* (Thaxter) Batko, *Z. echinospora* (Thaxter) Batko, *Z. exitalis* (Hall et Dunn) Batko, *Z. gloeospora* (Vuillemin) Batko (Batko 1964 c), *Z. vomitoriae* Rozsypal (1966), and two others for which I suggest new combinations:

Zoophthora (*Pandora*) *ferruginea* (Philips) comb. nov. (Basionym: *Entomophthora ferruginea* Philips, Ann. Mag. nat. Hist., Sér. 5, 18: 4, 1886) and *Zoophthora* (*Pandora*) *phalangioides* (Lagerheim) comb. nov. (Basionym: *Entomophthora phalangioides* Lagerheim, Bihang Svensk. Vetenskapskad. Akad. Handl. 24:12—15. 1898).

Zoophthora subg. *Furia* subg. nov.

Conidia maxima ex parte in classificatione Lakoni (1919) ad typum epapillata pertinentia. Conidiophori irregulariter ramosi, singularium ramorum partes apicales a conidiophoris transversis septis disjunctae et modo ampullari tumidae. Pseudocystidia desunt.

Typus subgeneris: *Zoophthora (Furia) virescens* (Thaxter) Batko, Bull. Acad. Polon. Sci., Sér. sci. biol. 12:406. 1964.

Conidia mostly of the epapillata type according to Lakon's (1919) classification. Conidiophores irregularly ramified, apical parts of the particular branchings separated from conidiophore by septa and bottlewise distended. Pseudocystides absent.

Type of subgenus: *Zoophthora (Furia) virescens* (Thaxter) Batko, (1964 c).

Etymology: *furia* (lat.) fury; name given to stress the destructive effect of the epizootia of this type species of the subgenus in populations of *Lepidoptera* caterpillars.

Monotypic subgenus, to the author's knowledge so far no other species of *Zoophthora* have been described which might be qualified to the subgenus *Furia*.

The author wishes to express his indebtedness to professor A. Skirgiełło for critical reading of this text, to the eminent writer J. Parandowski for suggesting some names for the subgenera described and to dr. W. Kałkowski for preparing the latin diagnoses of the new taxa.

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O podrodzajach rodzaju *Zoophthora* Batko 1964 (Entomophthoraceae)

Streszczenie

Autor ustala w obrębie rodzaju *Zoophthora* Batko (1964 a) cztery nowe podrodzaje: *Zoophthora* subg. *Zoophthora*, *Zoophthora* subg. *Erynia* (Nowakowski) subg. nov., *Zoophthora* subg. *Pandora* subg. nov. i *Zoophthora* subg. *Furia* subg. nov. Ponadto proponuje następujące nowe kombinacje: *Zoophthora* (*Zoophthora*) *bullata* (Povah) comb. nov., *Zoophthora* (*Zoophthora*) *sebrae* (Raunkiaer) comb. nov., *Zoophthora* (*Pandora*) *ferruginea* (Phillips) comb. nov. i *Zoophthora* (*Pandora*) *phalangicida* (Lagerheim) comb. nov.