

The genus *Vankya* (*Urocystidaceae*) revisited

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Abstract. An historical account of the smut genus *Vankya* and its type species, *V. ornithogali*, is given. It is apparent that *V. ornithogali* does not infect *Ornithogalum*, only species of *Gagea*, and that the genus *Vankya* is restricted to host plants in the *Liliaceae* s.str. It is shown for the first time that there are sterile cells between the spores of species of *Vankya*. Detailed descriptions of *Vankya* and its three species, including the new *V. lloydiae* on *Lloydia triflora*, are provided as well as synonyms, host plant ranges, geographic distributions and a key to the species. A lectotype is designated for *Ustilago heufleri*.

Key words: *Liliaceae*, new species, smut fungi, *Urocystidaceae*, *Vankya*, *V. heufleri*, *V. lloydiae*, *V. ornithogali*

Introduction

Ershad (2000: 66), based on Bauer *et al.* (1997), Begerow *et al.* (1998), Vánky (1994, 1997, 1998, and especially 1999), concluded that “true *Ustilago* species are restricted to host plants in the *Poaceae*”, and proposed a new genus *Vankya* for *Ustilago* species on *Liliaceae*, with the type *V. ornithogali* (J.C. Schmidt & Kunze) Ershad. Two additional species were transferred into this genus, *V. heufleri* (Fuckel) Ershad on species of *Tulipa* and *Erythronium*, and *V. vaillantii* (Tul. & C. Tul.) Ershad, on species of *Muscari*. Bauer *et al.* (2008), based on morphological & DNA analyses, demonstrated that the anthericolous *V. vaillantii*, on host plants in the *Hyacinthaceae*, is generically different from the other two foliicolous and caulicolous *Vankya* species on *Liliaceae*. They proposed a new genus, *Antherospora* R. Bauer, M. Lutz, Begerow, Piątek & Vánky, with the type *A. vaillantii* (Tul. & C. Tul.) R. Bauer, M. Lutz, Begerow, Piątek & Vánky. It was also demonstrated (Vánky *et al.* 2008) that *Antherospora*, together with the genus *Floromyces* Vánky, M. Lutz & R. Bauer, belongs to the family *Floromycetaceae* within the order *Urocystidales*, whereas *Vankya* is a member of the family *Urocystidaceae*.

A study of *Vankya ornithogali* and *V. heufleri* lead to some interesting results, which are explained below.

Materials and methods

Sorus structure and spore characteristics were studied using dried herbarium specimens, preserved in H.U.V. (Herbarium *Ustilaginales* Vánky). For light microscopy (LM), spores were suspended in a small droplet of lactophenol, covered with a cover glass, gently heated to boiling point to rehydrate the spores and eliminate air bubbles from the preparation, and studied at 1000× magnification. For scanning electron microscopy (SEM), spores were placed on double-sided adhesive tape, mounted on a specimen stub, sputter-coated with gold-palladium, ca 20 nm, and examined in a SEM at 10 kV.

Working hypothesis, results and discussion

To give an answer to the question what is *Vankya ornithogali* and what are its host plants, it is necessary to first look at the history of this smut.

A smut fungus was described by Schmidt & Kunze (1819) under the name *Uredo ornithogali* “in *Ornithogalis* primo vere”, from Germany. It was distributed in the exsiccata Schmidt & Kunze, Deutschlands Schwämme no. 217, 1819. Later, the

name was transferred into the genus *Ustilago*, and recently into the genus *Vankya*. The same fungus was described also under the names *Caeoma ornithogali* Schlechtendal (1824), on *Ornithogalum pratense* (= *Gagea pratensis*); *Ustilago ornithogali* Schröter, in Schneider (1869), on *Gagea minima*; *Ustilago umbrina* Schröter (1871), on *Gagea pratensis*; and *U. heterospora* Niessl (1872), on *Gagea bohemica*. Since 1819, the fungus has been collected from numerous countries on various *Gagea* species, on a few *Ornithogalum* species and also on *Lloydia triflora*.

Liro (1924: 114 & 526) discussed in detail the host plant of the type specimen and came to the conclusion, also based on Prof. Juel's opinion, that it was a species of *Gagea*, most probably *lutea*, which earlier was placed in the genus *Ornithogalum*.

In current classification schemes, the genera *Gagea* and *Lloydia* are members of the *Liliaceae* s. str., whereas *Ornithogalum* belongs to the *Hyacinthaceae*. Questions that arise are: 1. Can the same smut genus and even species (in this case *Vankya ornithogali*) parasitise host plants belonging to different families? 2. Are the host plants for the few reports of *V. ornithogali* on *Ornithogalum* and *Lloydia* correctly identified? 3. Do the smuts on *Ornithogalum*, *Gagea* and *Lloydia* represent the same species or not?

Ad 1. There are both polyphagous and strictly specialised genera and species of smut fungi known, e.g., species of the genus *Urocystis* (*Urocystidales*, *Urocystidaceae*) infect a wide range of both mono- and dicotyledonous host plants in 33 genera. Most *Urocystis* species are strictly host specific, some infect several species within the same genus, and a few occur on members of several, usually closely related host genera (comp. Vánky, 2009a, in press). All 8 known species of *Antherospora* (*Urocystidales*, *Floromycetaceae*) occur only on members of *Hyacinthaceae*, and usually each smut species infects only a single host plant genus (comp. Bauer *et al.* 2008; Vánky 2009a).

Ad 2. *Vankya ornithogali* has been reported on at least 29 species of *Gagea*. It has also been reported a few times on *Ornithogalum*. The host of the type of *V. ornithogali* is *Gagea lutea*, as mentioned above, and all occurrences on *Ornithogalum luteum* L. refer to *Gagea lutea* (L.) Ker Gawl. There is a collection of *Ustilago umbrina* on “*Ornithogalum umbellatum*” from Austria, Vienna, summer 1872, leg. J. Wallner, distributed in Thümen, Fgi. austr. no. 342. All copies of this exsiccata that I have seen, contain only smutted, narrow, relatively short leaves but no inflorescence or bulb. The host is certainly misidentified, most probably being a *Gagea* sp. In the exsiccata Litschauer & Lohwag, Fgi. sel. exs. eur. no. 151 is *Ustilago ornithogali* on “*Ornithogalum boucheanum* (Kth.) Asch.” from Austria, Wien, Schwarzenbergergarten, 10.V.1933, leg. K. & H. Lohwag. Vánky (1985: 226) demonstrated that it is *Ustilago heufleri* (= *Vankya heufleri*) on *Tulipa* sp. It is apparent that *V. ornithogali* does not occur on *Ornithogalum*.

Ad 3. Examination of a collection of “*Ustilago ornithogali*” on *Lloydia triflora*, showed that it is different

from *V. ornithogali* and it represents a new species of *Vankya*, described below.

A further species of *Vankya* is *V. heufleri*. It is known to occur on two closely related genera in the *Liliaceae*, namely on several species of *Tulipa* and *Erythronium*. No morphological differences of the sori and the spores (including sterile cells) could be found between the smuts on these two host genera. Therefore, I conclude that *V. heufleri* occurs on both *Tulipa* and *Erythronium* species. DNA analyses are necessary to confirm or disprove this conclusion.

Another surprising result, which escaped earlier observations, was that sterile cells are present (though in relatively few numbers) between the spores of all species of *Vankya*. These are solitary, rarely in groups of 2–3 (–4) or adhering to a spore, variable in size, usually smaller than the spores, pigmented, commonly somewhat paler than the mature spores. Their wall is thin or thick (depending on the size of the cells), not layered, and smooth. These must not to be confused with immature spores, which are paler, thin-walled, with a trace of ornamentation.

A complemented generic description of *Vankya*, as well as the descriptions of its three known species, illustrated also by their spores and sterile cells, are given below.

Vankya Ershad, Rostaniha 1: 66, 2000.

Sori on leaves and stems of host plants in *Liliaceae* s. str., forming pustules filled with blackish brown, powdery spore mass mixed with sterile cells, lacking peridium and columella. **Spores** single, pigmented (brown), without violet tint or pale yellow, orange or rusty colour. **Sterile cells** present between the spores, more or less pigmented, smooth, usually solitary. **Spore germination** results in phragmobasidia. **Host-parasite interaction** by haustoria. **Septal pore** simple with two membrane caps and two nonmembranous plates closing the pore. **Type:** *V. ornithogali*.

Vankya ornithogali (J.C. Schmidt & Kunze) Ershad, Rostaniha 1: 66, 2000.

Uredo ornithogali J.C. Schmidt & Kunze, Deutschl. Schwämme in getrockneten Exemplaren, Lief. 9: 5, 1819; in Schmidt & Kunze, Deutschl. Schwämme no. 217, 1819. — *Ustilago ornithogali* (J.C. Schmidt & Kunze) Magnus, Hedwigia 14: 19, 1875. — *Ustilago ornithogali* (J.C. Schmidt & Kunze) Kühn, in Rabenhorst, Fgi. eur. no. 1996, 1875. — Lectotype “in *Ornithogalis*” (= *Gagea lutea*?, det. Liro 1924: 114 & 526), Germany, (design. by Braun 1979: 410) Berlin, leg. J.C. Schmidt & G. Kunze, HAL. Isolectotypes in Schmidt & Kunze, Deutschl. Schwämme no. 217, HUV 13280!

Caeoma ornithogali Schlechtendal, Fl. Berol., Pars 2, Cryptogamia: 125, 1824. — Type on *Ornithogalum pratense* (= *Gagea pratensis*), Germany, Berlin (Syn. by Schlechtendal 1826: 239).

Ustilago ornithogali J. Schröt., in Schneider, Jahresber. Schles. Ges. Vaterl. Cult. 46: 142, 1869. (nom. nud.). — On *Gagea minima*, Germany, Schlesien.

Fig. 1. Sori of *Vankya lloydiae* on a leaf and stem of *Lloydia triflora* (type). Habit. Bar = 1 cm



Ustilago umbrina J. Schröter, Abh. Schles. Ges. Vaterl. Cult., Abth. Naturwiss. 1869/72: 3, 1869. — Lectotype on *Gagea* (design. by Vánky 1985: 225) *pratensis*, Germany, Silesia, Breslau [now Poland, Wrocław], Botanical Garden, May 1869, leg. Wildschütz, HUV 9327!; isoelectotypes in Schneider, Herb. schles. Pilze no. 180. Syntype on *G. minima*, Germany, Silesia, Liegnitz [now Poland, Legnica], no further data.

Ustilago heterospora Niessl, Verh. Naturf. Vereins Brünn 10: 158, 1872. — Lectotype on *Gagea bohemica*, Czech Rep., (design. by Vánky 1985: 226) near Brünn [= Brno], spring, leg. G. Niessl.

Sori on leaves and bracts forming 1–5 (–10) mm long, ellipsoidal or fusiform pustules, initially covered by the epidermis, which ruptures longitudinally to expose the blackish brown, powdery spore mass. Infection systemic, appearing year after year on the same host plant. **Spores** (Figs 2–3) varying in shape and size, subglobose, ovoid, irregular, subpolyhedral or elongate, not rarely with an acute tip, sometimes with a short pedicel, $9.5\text{--}15 \times 10.5\text{--}19$ (–24) μm , yellowish to reddish brown; wall $0.5\text{--}1.5$ μm thick, apparently one-layered, nearly smooth to finely, rather densely punctate-verruculose, the dots not affecting the spore profile. **Sterile cells** (Fig. 2) few, solitary or in groups of 2–4, subglobose, ellipsoidal, slightly irregular, rarely elongated, collapsed in old specimens, $11\text{--}20$ μm long, usually of the same colour as the spores; wall $1.5\text{--}3$ (–4) μm thick, one-layered, smooth, in SEM, at high magnification, rough.

On *Liliaceae* s. str.: *Gagea afghanica* Terr., *G. alexeenkoana* Misch., *G. arvensis* (Pers.) Dumort (*G. villosa* (M. Bieb.) Duby), *G. bohemica* (Zauschner) Schult. & Schult. f., *G. capusii* Terr., *G. chomutovae* (Pascher) Pascher, *G. confusa* Terracc., *G. conjungens* (Pascher) Vendelbo, *G. divaricata* Regel, *G. dshungarica* Regel, *G. dubia* Terracc., *G. dutaitii* Maire, *G. erubescens* Schult. f., *G. fascicularis* Salisb., *G. fistulosa* (Ramond ex DC.) Ker Gawl. (*G. liotardii* (Sternb.) Schult. & Schult. f.), *G. foliosa* (J. & C. Presl) Schult. & Schult. f., *G. gageoides* (Zucc.) Vved., *G. lutea* (L.) Ker Gawl. (*G. sylvatica* (Pers.) Loudon), *G. minima* (L.) Ker Gawl., *G. polymorpha* Boiss., *G. pratensis* (Pers.) Dumort (*G. stenopetala* Reichenb.; *Ornithogalum pratense* Pers.), *G. pusilla* (F.W. Schmidt) Schult. & Schult. f., *G. reticularis* Salisb., *G. reticulata* Schult. f., *G. saxatilis* (Mert. & Koch) Schult. & Schult. f., *G. spathacea* (Hayne) Salisb., *G. wilczekii* Braun-Blanq. & Maire.

Distribution: Europe (in numerous countries), N. Africa (Morocco), Asia (Azerbaijan, Georgia, Japan, Kazakhstan, Palestine, Turkmenistan).

***Vankya lloydiae* Vánky, sp. nov.**

Mycobank # MB 513082

Typus in matrice *Lloydia triflora* (Ledeb.) Baker, Russia, Primorsky Krai, Vladivostok, 13.V.1977, leg. N. Shaposhnikova. **Holotypus** in VLA 631, **isotypus** in HUV 18329! **Paratypus** *ibidem*, 18.V.1976, leg. Z.M. Azbukina, VLA 627, **isoparatypus** HUV 21549!

Sori pustulas caulium florumque atras, ovoideas vel elongatas, fusiformes, $0.5\text{--}1 \times 1\text{--}8$ mm, vel propter confluentiam longiores formantes, primum epidermide coopertas, quo rupto maturitate massam atrobrunneam, agglutinatam usque pulveream sporarum ostendentes. **Sporae** globosae, subglobosae, late ellipsoideales vel parum irregulares, $11\text{--}15$ (–16) $\times$ $13.5\text{--}18.5$ (–21) μm , mediocriter atro-rubescens; pariete aequaliter $2.5\text{--}3.5$ μm crasso, 2-stratoso, stratum interius crassum, pigmentosum, conspicue mediocriter dense verrucosum, verrucis $0.2\text{--}0.3$ μm altis, in strato externo tenui ($0.2\text{--}0.4$ μm), hyalino indusis. **Cellulae** steriles raras, plerumque solitariae, raro 2 vel 3 aggregatae, interdum ad sporam haerentes, subglobosae, ellipsoideales vel parum irregulares cum uno latere depresso, raro

elongatae, *magnitudine valde variabiles*, (6–) 7–13,5 × (6,5–) 8–16 (–20) μm , *pallide olivaceobrunneae*; *pariete* 1–3 (–4) μm *crasso*, *unistratusae*, *leves*.

Sori (Fig. 1) on the stems and leaves forming dark, ovoid or elongated, fusiform pustules, 0.5–1 × 1–8 mm, or longer by confluence, at first covered by the epidermis which ruptures at maturity disclosing the blackish brown, agglutinated to powdery mass of spores. **Spores** (Figs 4–5) globose, subglobose, broadly ellipsoidal or slightly irregular, 11–15 (–16) × 13.5–18.5 (–21) μm , medium dark reddish brown; wall evenly 2.5–3.5 μm thick, two-layered, inner layer thick, pigmented, evidently, moderately densely verrucose, warts 0.2–0.3 μm high, embedded in the outer, thin (0.2–0.4 μm), hyaline layer of the spores. **Sterile cells** (Figs 4–5) few, usually solitary, rarely in groups of two or three, sometimes adhering to a spore, subglobose, ellipsoidal or slightly irregular with a flattened side, rarely elongated, much variable in size, (6–) 7–13.5 × (6.5–) 8–16 (–20) μm , pale olivaceous brown; wall 1–3 (–4) μm thick, one-layered, smooth, in SEM, at high magnification, rough.

On *Liliaceae* (s. str.): *Lloydia triflora* (Ledeb.) Baker.

Distribution: E. Asia (Russia). Known only from the type locality.

Vankya lloydiae differs from *V. ornithogali* especially in having more regular and uniform, rounded spores, never with an acute tip, and in having a thicker, two-layered, more evidently verrucose spore wall.

Vankya heufleri (Fuckel) Ershad, Rostaniha 1: 68, 2000.

Ustilago heufleri Fuckel, Jahrb. Nassauischen Vereins Naturk. 23–24: 39, 1870. — Lectotype on *Tulipa sylvestris*, Austria, Wien, IV.1861, leg. L.J. Heufler (design. here) HUV 3713; isoelectotypes in Fuckel, Fgi. rhenani exs. no. 2304. Other (authentic?) material in Thümen, Fgi. austr. no. 16, HUV 11489!

Urocystis pompholygodes (Klotzsch) Rbh. f. *tulipae* Rabenhorst, Fgi. eur. no. 1099, 1866 (nom. nud.); Bot. Zeitung (Berlin) 24: 412, 1866 (nom. nud.). — *Ustilago tulipae* (Rabenhorst) G. Winter, Rabenh. Krypt.-Fl., 2 Aufl., 1(1): 86, 1881 (nom. illegit., superfl. pro *U. heufleri*). — Type on *Tulipa sylvestris*, Austria, Wien, leg. L.J. Heufler; isotypes in Rbh., Fgi. eur. no. 1099, HUV 3715!

Ustilago erythronii G.P. Clinton, in Peck, Bull. Buffalo Soc. Nat. Sci 1: 67, 1873. — *Ustilago ornithogali* (Schmidt

& G. Kze.) J.G. Kühn f. *erythronii* (G.P. Clinton) de Toni, in Saccardo, Syll. fung. 7: 452A, 1888. — Type on *Erythronium americanum*, USA, Goat Island, leg. G.P. Clinton (Syn. by Clinton 1906:20).

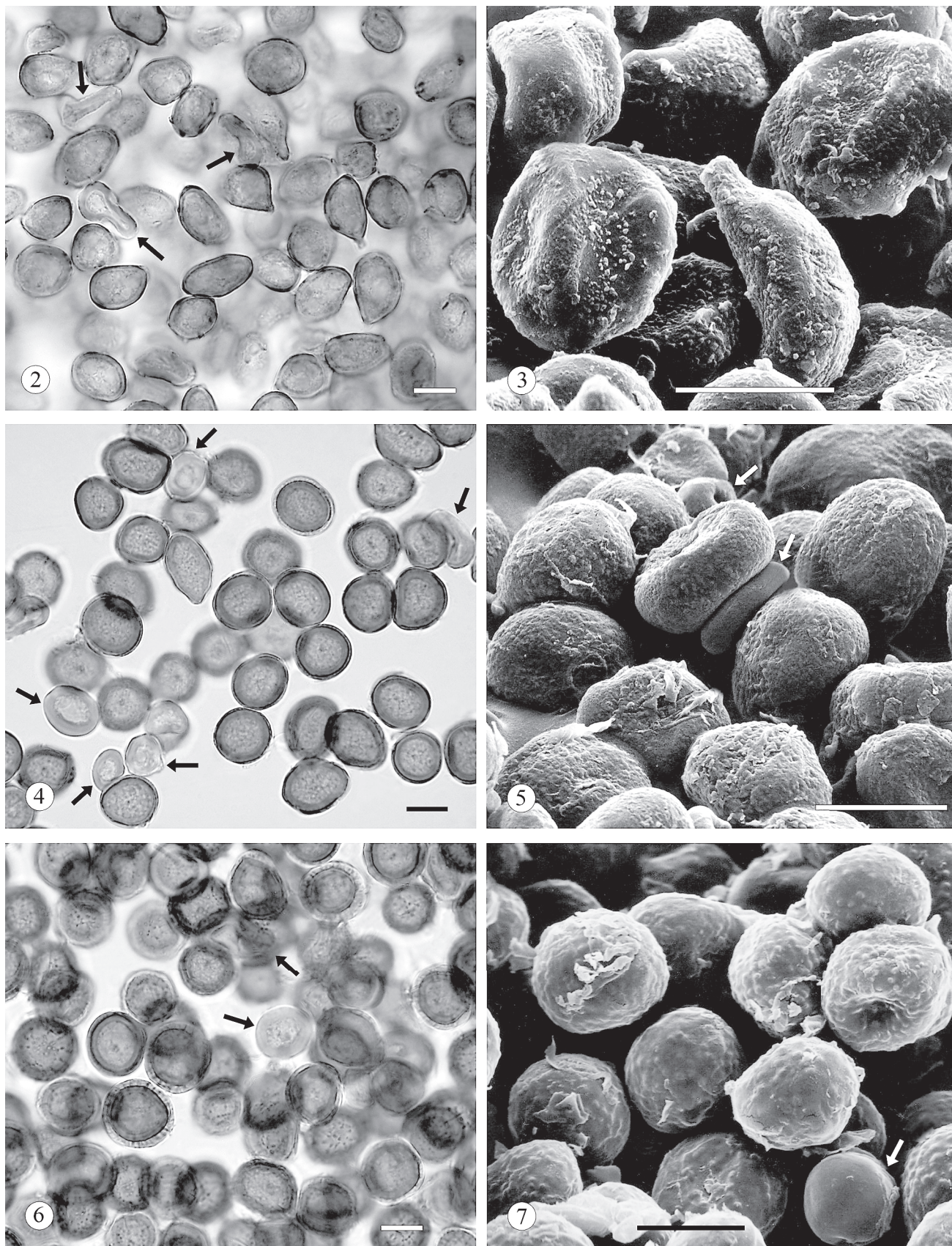
Sori in leaves as elongate pustules, initially covered by a thin, whitish membrane which ruptures irregularly and flakes away to expose the blackish brown, dusty spore mass. **Spores** (Figs 6–7) globose, subglobose to ovoid or slightly irregular, 13–19 × 15–23 μm , reddish brown; spore wall two-layered, inner layer dark brown, c. 0.5 μm thick, with sparsely, unevenly dispersed, 1–2 μm high spines, the spines often arranged in irregular rows or groups, embedded in the outer, yellowish brown, 1–2.5 μm thick layer, sometimes reaching the spore surface but never exceeding it, in SEM almost smooth or with sparsely or moderately densely situated, low and wide warts. **Sterile cells** (Figs 6–7) solitary, rarely in loosely connected pairs, subglobose, ellipsoidal to slightly irregular, collapsed in old specimens, 11–17 (–20) long, yellowish to pale olivaceous brown; wall evenly or slightly unevenly 1.5–3 (–4) μm thick, one-layered, smooth, in SEM, at high magnification, rough. **Spore germination** (Sartoris 1924), on water or nutrient media, was successful only if dried spores (3–4 weeks) were rehydrated in a moist chamber (for a few days), frozen in water for 2 days, and kept in oxygen for 10 hours. Basidia 4–5 × 70–80 μm , two- to four-septate, producing lateral, ovoid basidiospores which bud or germinate into hyphae. Basidiospores, judged from the drawings of Sartoris, are sessile.

On *Liliaceae*: *Erythronium albidum* Nutt., *E. americanum* Ker Gawl., *E. oregonum* Applegate, *Tulipa aleppensis* Boiss., *T. biebersteiniana* Schult. & Schult. f., *T. biflora* Pallas, *T. bifloriformis* Vved., *T. dubia* Vved., *T. edulis* Baker, *T. eichleri* Regel, *T. gesnerana* L., *T. humilis* Herbart, *T. julia* K. Koch, *T. micheliana* T.M. Hoog, *T. montana* Stapf, *T. montana* var. *chrysantha* (Boiss.) Wendelbo, *T. orientalis* Lev., *T. pavoninum* Schrenk, *T. polychroma* Stapf, *T. rhodopea* Velen., *T. saxatilis* Sieber ex Spreng., *T. schmidtii* Fomin, *T. schrenkii* Regel, *T. sogdiana* Bunge, *T. sosnowskyi* Achverd. & Mirzoeva, *T. sylvestris* L. (*T. ophiophylla* Klokov & Zoz), *T. sylvestris* subsp. *australis* (Link) Pamp. (*T. australis* Link), *T. urumoffii* Hayek.

Distribution: Europe (Austria, Bulgaria, France, Germany, Greece, Italy, Romania, Russia, Scotland), Asia (Azerbaijan, China, Dagestan, Georgia, Iran, Kazakhstan, Turkey, Turkmenistan, Uzbekistan), N America (Canada, USA).

Key to the species of *Vankya*

- 1 Spores mostly irregular, usually elongated, often acute; wall 0.5–1.5 μm thick, apparently one-layered, nearly smooth to finely, rather densely punctate-verruculose. On *Gagea* *V. ornithogali*
- 1* Spores rather regular, never acute; wall thicker, two-layered, evidently ornamented. Not on *Gagea* 2
- 2 Spores 13.5–18.5 (–21) μm long; wall 2.5–3.5 μm thick, verrucose; warts 0.2–0.3 μm high. On *Lloydia* *V. lloydiae*
- 2* Spores 15–23 μm long; wall 1.5–3 μm thick, with sparsely, unevenly dispersed, 1–2 μm high spines. On *Erythronium* and *Tulipa* *V. heufleri*



Figs 2–7. Spores and sterile cells of species of *Vankya* in LM and in SEM. Remark the sterile cells (arrows). Bars = 10 µm. 2–3. *Vankya ornithogali* on *Gagea pratensis* (Vánky, *Ust. exs.* no. 34). 4–5. *Vankya lloydiae* on *Lloydia triflora* (type). 6–7. *Vankya heufleri* on *Tulipa sylvestris* (type)

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