New records of smut fungi (*Ustilaginomycetes*) from Thailand, including two new species, *Sporisorium likhitekarajae* and *Tilletia isachneicola*

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Abstract. Several species of smut fungi not previously recorded in Thailand were collected in December 2007. Amongst these were two new species, *Sporisorium likhitekarajae* on *Ischaemum* sp. and *Tilletia isachneicola* on *Isachne globosa,* which are described and compared with related species.

Key words: new species, smut fungi, *Sporisorium likhitekarajae, Tilletia isachneicola, Ustilaginomycetes*

Introduction

Fifty-two species of smut fungi have been recorded from Thailand (Shivas *et al.* 2007). In December 2007, further specimens of smut fungi were collected, including several species previously not known to occur in Thailand. Amongst these specimens were two smut fungi, *Tilletia* on *Isachne globosa* and *Sporisorium* on *Ischaemum* sp., which represented new species. These two species are described and illustrated below.

Material and Methods

Spore and spore characteristics were studied using living and dried specimens. For light microscopy the specimens were mounted in lactoglycerol, gently heated and examined with a compound microscope (Leica DM 2500). Figures 3 and 5 are each composed of two images created using depth of field combination software (Auto-Montage Pro ver. 5.02, Syncroscopy, Cambridge, UK) to enhance image quality. For scanning electron microscopy (SEM), dry spores were dusted on double-sided adhesive tape, mounted on a specimen stub, sputter-coated with gold-palladium, c. 20 nm, and examined in a SEM (JEOL 6300) at 10 kV. Specimens have been deposited in the herbaria BRIP, H.U.V. (Herbarium *Ustilaginales* Vánky, Tübingen, Germany) and TPPH (Thai Plant Pathology Herbarium, Bangkok, Thailand).

Taxonomy

Sporisorium likhitekarajae R.G. Shivas, Athipunyakom & McTaggart, **sp. nov.** **Figs 1, 3-4**
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Sori *in omnibus spiculis inflorescentiae, delentes intima florum femineorum organa floralia, partim celati extimis involucris floralibus, primo tecti peridio flavido-brunneo quod irregulariter passim rumpitur, detegens massam pilarum sporarum fuscam granularem pulveraceam et multas columellas filiformes, saepe anastomosantes.* ***Pilae sporarum*** *permanentiores, variabiles forma et amplitudine, subglobosae, ovoideae, elongatae irregulareve, 30-120 × 25-70 µm, fuscae-testaceae ad subopacae, formatae ex sporis denis ad centenis.* ***Sporae*** *subglobosae, ovoideae, ellipsoideae ad paulum irregulares, subpolyhedrales, 8,0-13,5 × 6,5-10,0 µm, dimorphae;sporae exteriores fuscae-testaceae; paries inaequalis, 0,5-2,0 µm densus, densius punctuatus ad verruculosus in pagina libera, levis in lateribus contactis, sporarum facies levis, in pagina libera undulata ad subtiliter serrulata; sporae interiores flavidae-brunneae; paries planus, c. 0,5 µm densus, levis.* ***Cellulae steriles*** *absentes.*

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Type on *Ischaemum* sp., Thailand, Nakhon Phanom Prov., Sri Songkram District, 31 km W of Sri Songkram, 17°42'28" N, 104°17'10" E, 12 Dec 2008, coll. P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, A.J., G.F., M.D.E. & R.G. Shivas. **Holotype** in BRIP 51 521, isotypes in H.U.V. 21 517, TPPH 02 247.

Sori in all of the spikelets of an inflorescence, destroying the innermost floral organs of female flowers, partly hidden by the outermost floral envelopes, initially covered by a yellowish brown peridium which ruptures irregularly in many places disclosing the dark brown, granular powdery mass of spore balls and numerous, filiform, often anastomosing columellae. **Spore balls** rather permanent, variable in shape and size, subglobose, ovoid, elongated or irregular, 30-120 × 25-70 µm, dark reddish-brown to subopaque, composed of tens to hundreds of spores. **Spores** subglobose, ovoid, ellipsoidal to slightly irregular, subpolyhedral, 8.0-13.5 × 6.5-10.0 µm, dimorphic; outer spores dark reddish-brown; wall uneven, 0.5-2.0 µm thick, moderately densely punctuate to verruculose on the free surface, smooth on contact sides, spore profile smooth, on the free surface wavy to finely serrulate; inner spores light yellowish-brown; wall even, c. 0.5 µm thick, smooth. **Sterile cells** absent.

On *Poaceae: Ischaemum* sp.

Distribution: known only from the type collection.

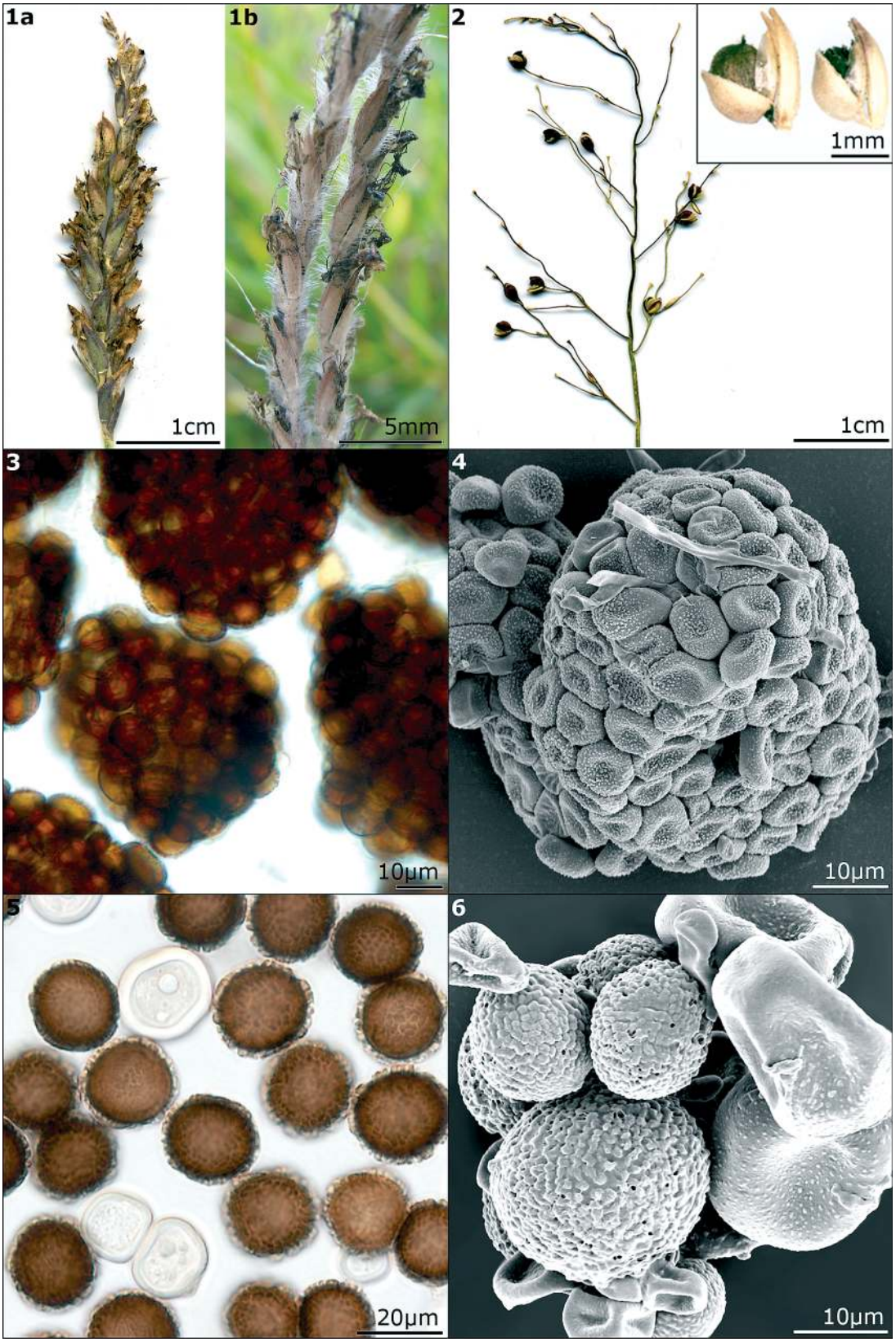
Etymology: named after the Thai plant pathologist Ms Srisurang Likhitekaraj.

Ischaemum L. (in the subfam. *Panicoideae,* tribe *Andropogoneae*) has about 65 species, which mostly occur in the tropics and subtropics of Asia (Mabberley 1998). Vánky (2007) provided a key for the eleven known species of *Sporisorium* on *Ischaemum*, namely (1) *S. flagellatum* (Syd., P. Syd. & Butler) Vánky (type on *I. timorense* in India); (2) *S. furcatum* (Syd., P. Syd. & Butler) Vánky (type on *I. aristatum* in India); (3) *S. hainanae* (Zundel) L. Guo (type on *I. tonglinensis* in China); (4) *S. ischaemi* (L. Ling) Vánky (type on *I. rugosum* in India); (5) *S. ischaemi-anthephoroidis* (S. Ito) Vánky & Kakish. (type on *I. anthephoroides* in Japan); (6) *S. ischaemianum* A.R. Patil, T.M. Patil & M.S. Patil (type on *Ischaemum* sp. in India); (7) *S. ischaemicola* (L. Ling) Vánky (type on *I. timorense* in Papua New Guinea); (8) *S. ischaemi-rugosi* (J.N. Mishra) Vánky (type on *I. rugosum* in India); (9) *S. myanmarense* Vánky & Shivas (type on *I. indicum* in Burma); (10) *S. semisagittatum* (Thirum. & Pavgi) Vánky (type on *I. semisagittatum* in India); and (11) *S. tonglinense* (Tracy & Earle) L. Guo (type on *I. indicum* in India).

Of all of the species of *Sporisorium* that occur on *Ischaemum, S. likhitekarajae* and *S. furcatum* are the only two that have rather permanent spore balls. *S. likhitekarajae* has dimorphic spores and lacks sterile cells, thereby differing from *S. furcatum.*

Key to species of ***Sporisorium*** on ***Ischaemum***
(modified from Vánky 2007)

1	Sori in the spikelets	**2**
1*	Sori in the whole inflorescence	**9**
2	Sori in some spikelets	***S. semisagittatum***
2*	Sori in all spikelets of an inflorescence	**3**
3*	Spore balls rather permanent	**4**
3	Spore balls ephemeral or loose	**5**
4	Columellae several, filiform, often anastomosed; spores dimorphic; sterile cells absent	***S. likhitekarajae***
4*	Columella one, stout; spores not dimorphic; sterile cells present	***S. furcatum***
5	Spores 8-10 µm long	***S. hainanae***
5*	Spores larger	**6**
6	Spores 10.5-15 µm long; wall unevenly thick	***S. ischaemicola***
6*	Spores smaller or larger but spore wall evenly thick	**7**
7	Spores prominently echinulate, profile serrate	***S. tonglinense***
7*	Spores finely echinulate, profile finely serrulate	**8**
8	Sori 4-6 mm long; spores mostly subpolyhedral	***S. ischaemi***
8*	Sori 1.5-2 mm long; spores globose to broadly ellipsoidal	***S. myanmarense***
9	Spores 5-7 µm long, flattened on one side, apparently smooth to very finely punctuate	***S. ischaemi-anthephoroides***
9*	Spores larger, not flattened on one side, evidently ornamented	**10**
10	Columellae several, filiform; spores dimorphic; sterile cells absent	***S. ischaemianum***
10*	Columella one; spores not dimorphic; sterile cells present	**11**
11	Columella long, flagelliform; spores 12-19 µm long	***S. flagellatum***
11*	Columella stout, with shortly bifurcate tip; spores 11-13.5 µm long	***S. ischaemi-rugosi***



Figs 1, 3-4. ***Sporisorium likhitekarajae*** (BRIP 51 521). **Fig. 1(a).** Herbarium specimen (scale = 5 mm). **Fig. 1(b).** Field symptoms (scale = 5 mm). **Fig. 3.** Spore balls and spores under light microscope (scale = 10 µm). **Fig. 4.** Spore ball and spores under SEM (scale = 1 µm). **Figs 2, 5-6.** ***Tilletia isachneicola*** (BRIP 51 503). **Fig. 2.** Host symptoms (scale = 1 cm); infected florets (insert, scale = 1 mm). **Fig. 5.** Spores and sterile cells under light microscope (scale = 10 µm). **Fig. 6.** Spores and sterile cells under SEM (scale = 1 µm)

Tilletia isachneicola R.G. Shivas, Athipunyakom & McTaggart, **sp. nov.** **Figs 2, 5-6**
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Sori *in nonnullis ovariis inflorescentiae, manifesti inter involucra floralia patentia, globoidei, 1-1,5 mm diametro, primo virides, postea brunnei, tandem peridium apicaliter patescit, detegens atram, pulveraceam massam sporarum mixtarum cellulis sterilibus.* ***Sporae*** *globosae, subglobosae, ovoideae, ellipsoideae vel paulum irregulares, 16-24 × 17-26 m, olivaceae-brunneae ad fuscae; paries 1,5-3,5 µm densus, cum dense sitis, 1-2 µm altis verrucis apice obtuso complanatove, verrucae superficiali aspectu videntur atriores, irregulariter polyangulares subpolyangularesve areae, 10-16 per sporae diametrum, opticali mediano aspectu 30-50 in sporae ambitu.* ***Cellulae steriles*** *subglobosae, ellipsoideae vel subpolyhedraliter irregulares, variabiles amplitudine, 7-30 × 11-35 µm, subhyalinae vel flavido-brunneo colore; paries 1,5-5,0 µm densus, levis, dense punctuatus ad aspere verrucosus.*

Type in ovaries of *Isachne globosa* (Thunb.) O. Kuntze, Thailand, Phang Nga Province, Takua Pa District, 2 km S of Takua Pa, 8°48'24" N, 98°22'03" E, 8 Dec 2007, coll. P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, P. Patanavipart, S. Seemadua, A.J., G.F., M.D.E. & R.G. Shivas. **Holotype** in BRIP 51 503, isotypes in H.U.V. 21 518, TPPH 02 233.

Sori in some ovaries of an inflorescence, showing between the spreading floral envelopes, globoid, 1-1.5 mm diameter, initially green, later brown, at maturity the peridium opens apically exposing the black, powdery mass of spores intermixed with sterile cells. ***Spores*** globose, subglobose, ovoid, ellipsoidal or slightly irregular, 16-24 × 17-26 µm, medium to dark olivaceous brown; wall 1.5-3.5 µm thick, including the densely situated, 1-2 µm high warts with blunt or flattened tip, warts in surface view appear as darker, irregularly polyangular or subpolyangular areas, 10-16 per spore diam, in optical median view 30-50 on the spore circumference. ***Sterile cells*** subglobose, ellipsoidal or subpolyhedrally irregular, variable in size, 7-30 × 11-35 µm, subhyaline or with yellowish brown tint; wall 1.5-5.0 µm thick, smooth, densely punctate to roughly verrucose.

On *Poaceae: Isachne globosa*.

Distribution: known only from the type collection.

Isachne R. Br. (in the subfam. *Panicoideae,* tribe *Isachneae*) has about 50 species, which mostly occur in the tropics and subtropics of Asia (Mabberley 1998). *Isachne globosa* is a minor weed of rice fields in Thailand and elsewhere in south-east Asia (Soerjani *et al.* 1987). Only one other species of *Tilletia* (*T. isachnes* A.R. Patil, T.M. Patil & M.S. Patil, Indian Phytolopathology **59**: 81, 2006; type on *Isachne lisboae* Hook. f. in India) is known to occur on *Isachne. T. isachnes* differs from *T. isachneicola* in having larger spores (21.5-29 × 21.5-28 µm), with fewer blunt warts i.e. 8-12 per spore diameter, in optical median view 30-40 on the spore circumference.

Key to species of *Tilletia* on *Isachne*

1 Spores 16-26 µm long; warts 1-2 µm high, 10-16 per spore diameter ..... ***T. isachneicola***
1* Spores 21.5-29 µm long; warts 1.5-2.5 µm high, 8-12 per spore diameter ..... ***T. isachnes***

New records

New records of smut fungi not previously known to occur in Thailand (Shivas *et al.* 2007) follow.

Dermatosorus eleocharidis Sawada ex L. Ling, Mycologia **41**: 268 (1949).

On *Eleocharis dulcis* (Burm. f.) Trin ex Hensch.: Luna Phuket, Phuket Prov., 10 Dec 2007, P. Athipunyakom, S. Likhitekaraj, T.S. Marney, A.R. McTaggart, P. Patanavipart, S. Seemadua & R.G. Shivas (BRIP 51 511, H.U.V. 21 519, TPPH 02 242).

Eriocaulago jagdishwari (Mishra) Vánky, Mycol. Balcan. **2**: 114 (2005).

On *Eriocaulon* sp.: 20 km W of Sri Songkram, Nakhon Phanom Prov., 12 Dec 2007, P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, A.J., G.F., M.D.E. & R.G. Shivas (BRIP 51 519, H.U.V. 21 520, TPPH 51 519).

Macalpinomyces bursus (Berk.) Vánky, Mycotaxon **81**: 427 (2002).

On *Themeda villosa* (Poir.) A. Camus: 42 km E of Chiang Saen, Chiang Rai Prov., 16 Dec 2007, P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, A.J., G.F., M.D.E. & R.G. Shivas (BRIP 51 544, TPPH 02 267); Wiang Chiang Rung, Chiang Rai Prov., 17 Dec 2007, P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, A.J., G.F., M.D.E. & R.G. Shivas (BRIP 51 552, H.U.V. 21 521).

Themeda villosa is a new host plant for *M. bursus.*

Macalpinomyces ewartii (McAlpine) Vánky & R.G. Shivas, Mycotaxon **80**: 346 (2001).

On *Sorghum nitidum* (Vahl) Pers.: 20 km S of Chun, Pha Yao Prov., 15 Dec 2007, P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, A.J., G.F., M.D.E. & R.G. Shivas (BRIP 51 538, H.U.V. 21 522, TPPH 02 262).

Pilocintractia adrianae Vánky, Mycotaxon **95**: 54 (2006).

On *Fimbristylis miliacea* (L.) Vahl: 91 km SW of Pha Yao, Phrae Prov., 15 Dec 2007, P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, A.J., G.F., M.D.E. & R.G. Shivas (BRIP 51 535, H.U.V. 21 528, TPPH 02 260).

Pilocintractia fimbristylidicola (Pavgi & Mundk.) Vánky, Mycol. Balcan. **1**: 173 (2004).

On *Fimbristylis bisumbellata* (Forssk.) Bubani: 131 km N of Chum Phon, Prachuap Khiri Khan Prov., 6 Dec 2007, P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, P. Patanavipart, S. Seemadua, A.J., G.F., M.D.E. & R.G. Shivas (BRIP 51 494, H.U.V. 21 525).

Sporisorium berndtii Vánky, Mycotaxon **85**: 37 (2003).

On *Schizachyrium sanguineum* (Retz.) Alston: Mae Ngad Dam, Mae Taeng Distr., Chiang Mai Prov., 19 Dec 2007, P. Athipunyakom, S. Likhitekaraj, T.S. Marney, A.R. McTaggart & R.G. Shivas (BRIP 51 559, H.U.V. 21 523).

This is the second report of *S. berndtii,* in addition to the type specimen from Sumatra.

Sporisorium exsertum (McAlpine) L. Guo, Mycosystema **3**: 80 (1990).

On *Themeda triandra* Forssk.: Wiang Chiang Rung, Chiang Rai Prov., 17 Dec 2007, P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, A.J., G.F., M.D.E. & R.G. Shivas (BRIP 51 550, H.U.V. 21 524).

Sporisorium tenue (Syd. & P. Syd.) Vánky, Fungal Diversity **15**: 238 (2004).

On *Bothriochloa bladhii* (Retz.) S.T. Blake: 3 km E of Chat Trakan, Phitsanulok Prov., 13 Dec 2007, P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, A.J., G.F., M.D.E. & R.G. Shivas (BRIP 51 523, TPPH 02 250).

Tilletia sp.

On *Sacciolepis indica* (L.) A. Chase: Sai Mun, Sakon Nakhon Prov., 11 Dec 2007, P. Athipunyakom, S. Likhitekaraj, V.L. Challinor, T.S. Marney, A.R. McTaggart, A.J., G.F., M.D.E. & R.G. Shivas (BRIP 51 514).

Only a single sorus of this smut fungus was found. There are no reports of *Tilletia* on *Sacciolepis.*

Trichocintractia utriculicola (Henn.) M. Piepenbr., Canad. J. Bot. **73**: 1095 (1995).

On *Rhynchospora corymbosa* (L.) Britton: Lahan Sai Distr., Buri Ram Prov., 23 Jun 2006, P. Athipunyakom (TPPH 01 623); 29 km N of Chum Phon, Tha Sae Distr., Chum Phon Prov., 6 Feb 2006, P. Athipunyakom (TPPH 01 241); 137 km N of Phuket, Takua Pa Distr., Phang Nga Prov., 7 Feb 2006, P. Athipunyakom, P. Trakunsukharat & S. Likhitekaraj (TPPH 01 237); 8 km S of Khao Phanom Distr., Krabi Prov., 7 Feb 2006, P. Athipunyakom (TPPH 01 250).

Ustilago esculenta Henn., Hedwigia **34**: 10 (1895).

On *Zizania latifolia* (Griseb.) Turcz.: Rice Research Station, Krabi, Krabi Prov., 9 Dec 2007, P. Athipunyakom, S. Likhitekaraj, T.S. Marney, A.R. McTaggart, P. Patanavipart, S. Seemadua & R.G. Shivas (BRIP 51 508, H.U.V. 21 526, TPPH 02 234).

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