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# *Climacodon pulcherrimus* a badly known tropical species, present in Europe

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**Abstract** – *Climacodon pulcherrimus*, a polymorphous species with a large distribution and habitat, is described macro- and microscopically. Its uncertain taxonomic position has led to the description of many synonymous species and placement in different genera. The type species of *Hydnum pulcherrimum* Berk. & M.A. Curtis is examined for the first time and it is compared with other collections from Malay Peninsula, Pakistan, USA and Spain. The study of Spanish collections enlarges the distribution to the South of Europe.

***Basidiomycota* / *Meruliaceae* / *Climacodon* / *Donkia* / *Hydnum* / systematics / chorology / taxonomy**

## INTRODUCTION

In the last four years, we have collected some basidiomata of a saprophyte fungus with a basidioma of medium size, normally dimidiate with trametoid appearance and hydnoid hymenophore. Microscopically it is characterized by the presence of double or multiple clamp connections, ellipsoid basidiospores and absence of cystidia. Finally, we could determine it, with some difficulties, as a member of the genus *Climacodon* P. Karst., belonging to the family *Meruliaceae* P. Karst., order *Polyporales* Gäum. (Kirk *et al.*, 2001). This genus includes species with conspicuous cystidia and hyphae with single clamp connections, with the only exception of *C. pulcherrimus* (Berk. & M.A. Curtis) M.I. Nikol., collected by us. For these reasons its inclusion in *Climacodon* is very conflictive and its taxonomic insertion is very difficult.

*Climacodon pulcherrimus* is a polymorphous species with a wide distribution and habitat, therefore there are many descriptions under different names which were synonymized by Maas Geesteranus (1971). *Hydnum pulcherrimum* Berk & M.A. Curtis, basonym of *Climacodon pulcherrimus*, has been characterized depending on the differing interpretations. According to Maas Geesteranus (1971) it has gloeocystidia that sometimes are not developed and

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double or multiple clamp connections. Pilát (1936) described it with leptocystidia without any reference to the presence of clamp connections. Recently, Gibertoni *et al.* (2004) has commented on the presence of gloeocystidia but provides no information about the characteristics of clamp connections.

On the other hand, *Hydnum pulcherrimum* has been recombined into such genera as *Steccherinum*, *Creolophus*, *Dryodon* and *Donkia*, but has not been included in *Phanerochaete*, although it shares some characters with this genus (Nakasone, 1990).

The above comments indicate the necessity to study the type material of *Hydnum pulcherrimum* deposited in the herbarium K, and not studied by Maas Geesteranus (1971), in order to clarify the taxonomic problems.

The study of Spanish collections has enlarged the distribution to the South of Europe.

## MATERIAL AND METHODS

The specimens examined are kept in the following herbaria: AH, ARAN-Fungi, BIO-Fungi, K, L, UPS and LLoyd Mycological collection in BPI.

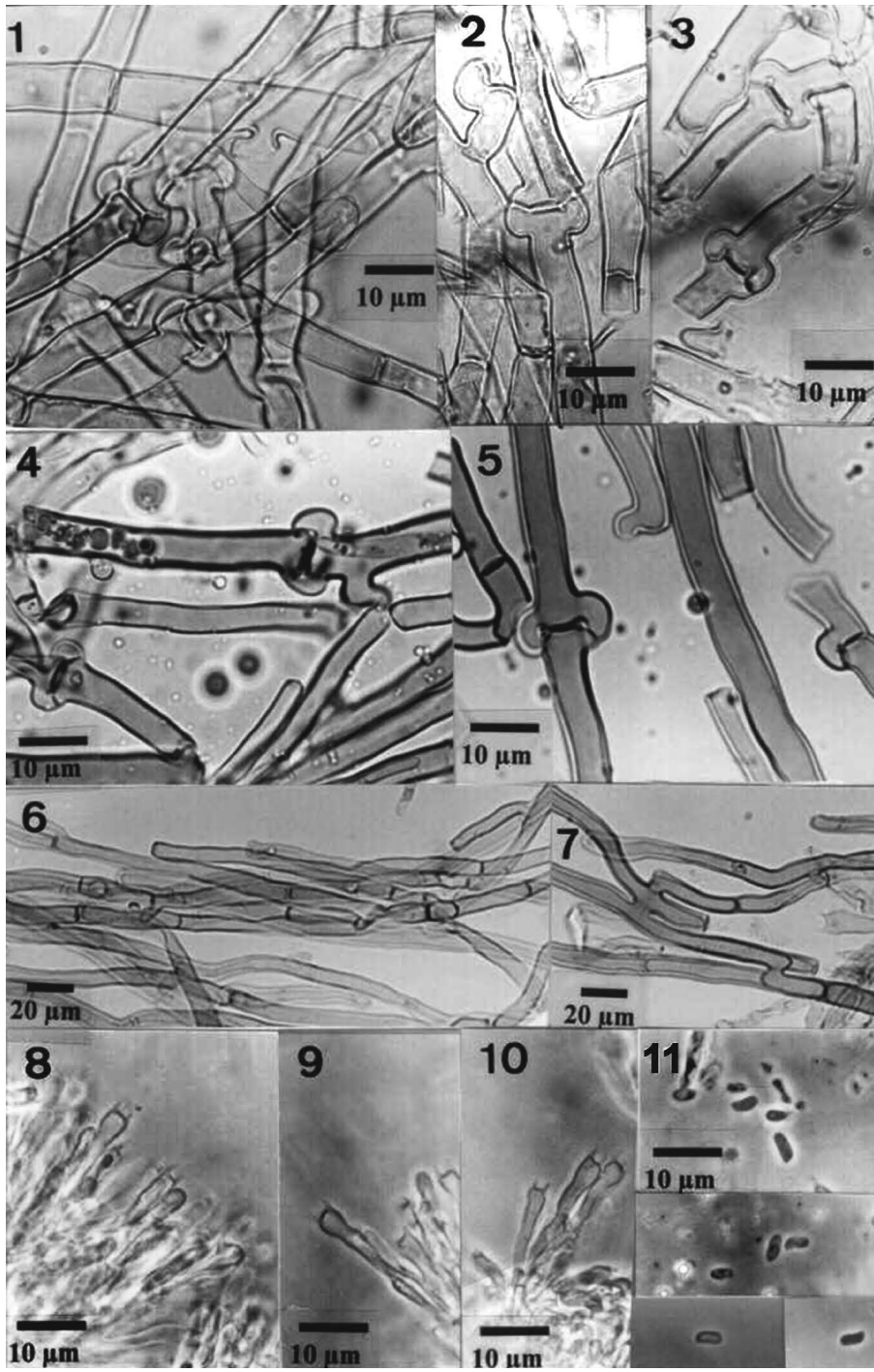
The material collected was studied with a binocular microscope and after mounting in KOH 5% and ammoniacal Congo red solution. Spore measurements were made under the oil immersion objective. The micrographs have been made with a Nikon (Eclipse 80i) microscope and a digital camera Nikon (DS-5M).

The abbreviations for author citations follow Kirk & Ansell (2003).

## TAXONOMY

***Climacodon pulcherrimus* (Berk. & M.A. Curtis) M.I. Nikol.**, *Flora Plantarum Cryptogamarum URSS 6*, Fungi 6 (Fungi, 2): 194 (1961) (Figs. 1-11; 16-19)
≡ *Hydnum pulcherrimum* Berk. & M.A. Curtis, *Hooker's J. Bot. Kew Gard. Misc.* 1: 235 (1849)
≡ *Steccherinum pulcherrimum* (Berk. & M.A. Curtis) Banker, *Mem. Torrey Bot. Club* 12: 129 (1906)
≡ *Creolophus pulcherrimus* (Berk. & M.A. Curtis) Banker, *Mycologia* 5(6): 294 (1913)
≡ *Dryodon pulcherrimus* (Berk. & M.A. Curtis) Pilát [as "*pulcherrimum*"], *Bull. trimest. Soc. mycol. Fr.* 49: 315 (1934)
≡ *Donkia pulcherrima* (Berk. & M.A. Curtis) Pilát, *Bull. trimest. Soc. mycol. Fr.* 52(3): 328 (1936)
= *Hydnum gilvum* Berk., *Hooker's J. Bot. Kew Gard. Misc.* 3: 168 (1851)
= *Hydnum uleanum* Henn., *Hedwigia* 36: 198 (1897)
= *Hydnum kauffmanii* Peck [as "*kauffmani*"], *Bull. Torrey bot. Club* 34: 348 (1907)
= *Hydnum australe* Lloyd, *Mycol. Writ. 5* (*Letter 69*): 11 (1919)
= *Hydnum duriusculum* Lloyd, *Mycol. Writ.* 7: 1107 (1922)

**Material studied: Spain:** Hernani, Ugaldetxo, Gipuzkoa, fallen trunk of *Quercus rubra*, 02-VII-2002, *leg*. J.M. Lekuona, ARAN-Fungi A0000412. Barrutia, Gernika, Bizkaia, fallen trunk of *Quercus robur*, 16-IX-2005, *leg*. R. Picón & I. Salcedo, BIO-Fungi 10896. Goizueta-Exkax, Navarra, woody residues of *Fagus sylvatica*, 8-VII-2000, *leg.* J.M. Lekuona,




Figs. 1-11 *Climacodon pulcherrimus* AH 31379. 1-3: Contextual hyphae. 4-5. Hyphae of the pileipellis. 6-7: Hyphae of the subhymenium. 8: Detail of the hymenium. 9-10: Basidia. 11: Spores.

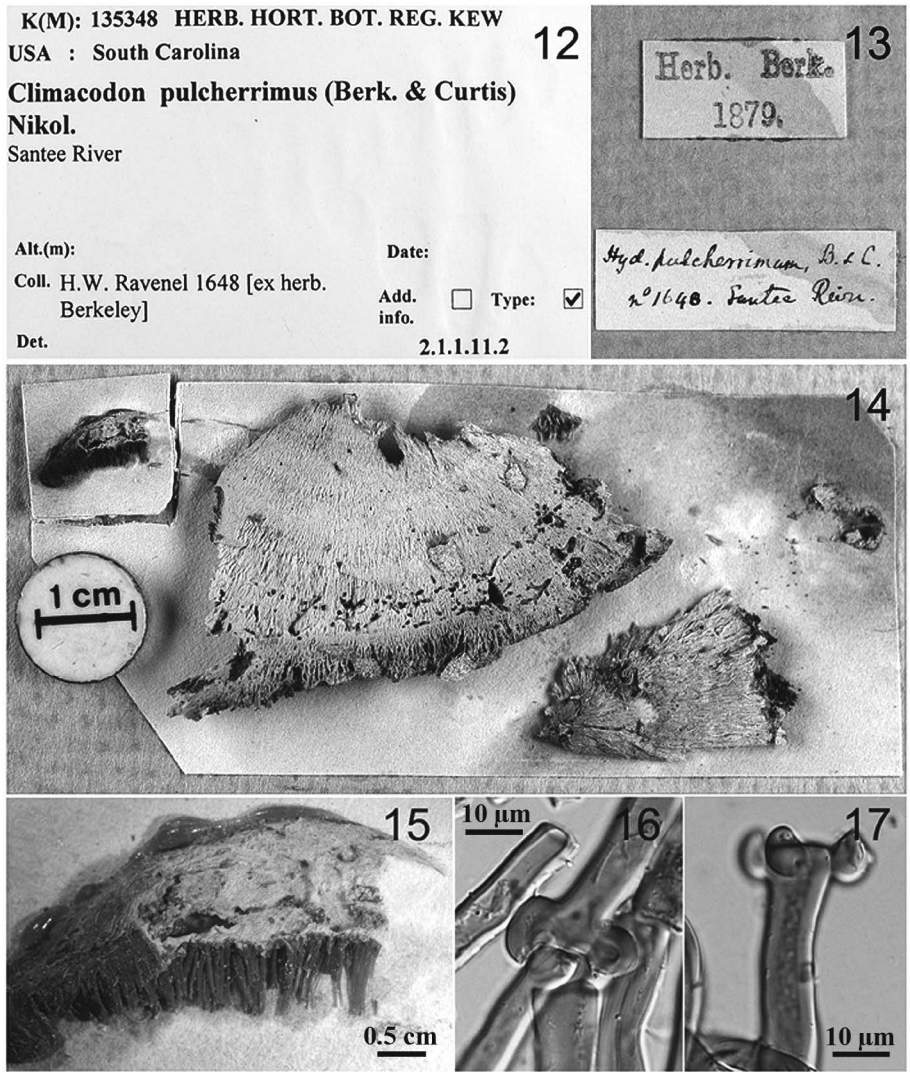
ARAN-Fungi L0002309. Abaño, Arano, Navarra, dead trunk of *Quercus rubra*, 27-VI-2002, *leg*. J.M. Lekuona, ARAN-Fungi A0000403. Jimena de la Frontera, Cádiz, dead branches of *Quercus suber*, 2-XI-2003, *leg.* M. Madrid, AH 31379 duplicate in the herbarium of Ryvarden, Larsson & Bernicchia. Ronda, pinar Arroyo del Águila, National Park of Grazalema, Málaga, trunk of *Quercus ilex*, 4-XII-2003, *leg.* F. Prieto & M.A. González, AH 31738 duplo in BIO-Fungi 11031. Artikutza-Elama, Navarra, 30T WN9881, 450 m, woody residues of *Corylus avellana*, 24-VII-2004, *leg.* J.M. Lekuona, J. Huarte, P.M. Pasaban, J.L. Albisu, A. Iñiguez & I. Olariaga, ARAN-Fungi 5011101A. Jimena de la Frontera, Cádiz**,** dead branches of *Quercus suber*, 27-XI-2004, *leg.* F. Prieto & M.A. González, AH 31805. **U.S.A.**: South Carolina, Santee River, coll. H.W. Ravenel 1648 (ex herb. Berkeley), K 135348 Type *Hydnum pulcherrimum* Berk. & M.A. Curtis. Florida, Seminole lo., Altamonte springs. On decaying oak log. 25-X-1961, *leg*. Paul O. Schallot, in UPS. **Brazil**: Mamamguape Municipality, Paraíba State, Reserva Biológica Guaribas, Mata Cabeça de Boi, on dead hardwood, III-2002, *leg*. Tatiana B. Gibertoni 22 in herb. Ryvarden 17620. **Malay Peninsula**: Singapore, Botanical Gardens, in clusters of horizontal branchets, 1-IX-1913, *leg.* E.M. Burkill, Mm. Burkill's 88, 4923 Lloyd in BPI US0324672 Type *Hydnum duriusculum* Lloyd. *Idem*, Isotype L 0628153. Botanical Gardens, Straits Settlements, at base of living *Hevea brasiliensis*, 15-VI-1914, *leg.* E.M. Burkill, Mm. Burkill's 345, 4865 Lloyd in BPI US0324671. Pahang, Tembeling, 7-XI-1930, *leg.* E.J.H. Corner, Herb. Lugd. Batav. 24162 in L 0628155. *Ibidem*, 17-XI-1930, Herb. Lugd. Batav. 24184 in L 0628157. Pahang, Sungei Cheka, 12-VI-1931, *leg.* E.J.H. Corner, L 0628154; Singapore, Botanical Gardens, 16-II-1932, *leg.* E.J.H. Corner, L 0628152; Johore, Mawai, 2-IX-1934, *leg.* E.J.H. Corner, L 0628156. **Pakistan**: Swat, Sharhan, on decayed log, 24-VIII-1959, *leg.* S.Ahmad, Herb. Lugd. Batav. 14407 in L 0628151.

Basidiocarps solitary, often imbricated, 3.5-11 × 2-6 cm, broadly attached to the substrate, dimidiate, semicircular, flattened, up to triangular in section, upper surface pale brownish with orange or orange-reddish tints, tomentose, azonate, margin concolorous. Hymenophore hydnoid, orange-cream to pale orange brown, sometimes with caramelized aspect in herbarium material, teeth up to 6 × 1 mm, joined at the base, cylindrical to somewhat flattened, with acute ends without branches, sometimes slightly ciliate or tuberculate. Context white to brownish, soft, 2-5 mm. Smell scarcely notable. Flavour to fungi hardly relevant.

Hyphal system monomitic; contextual hyphae hyaline, thin to thick walled, 4-6-(-8) µm, septate, occasionally branched, afibulate or with 1-2(-5) clamps in each septum. Hyphae of the pileipellis 7-9 µm diameter, double walled, hyaline, sometimes with oily content, septate, afibulate or with 1-2-3-4 (-5) clamps in each septum. Hyphae of the trama of the teeth 3-4 µm diameter, parallel, septate, hyaline, sometimes with abundant oil drops, without or with very scanty clamps. Hyphae of the subhymenium 2.5-3 µm, with prismatic texture, without clamps. Basidia (15-)20-30 × 4-4.5 µm, subclavate to cylindrical, hyaline, thin walled, tetrasporic, without clamps at the base. Cystidia lacking, with some hyphal ends with obtuse apex, projecting from the hymenium which are visible with stereoscopic microscopy, giving a velutinous appearance. Basidiospores 4-5(-6) × 1.5-2(-2.8) µm, ellipsoid to allantoid, hyaline, smooth, thin walled, non-amyloid, non-dextrinoid. Oil drops are very common in the hymenophore, mainly in the trama.

## STUDY OF THE TYPE MATERIAL

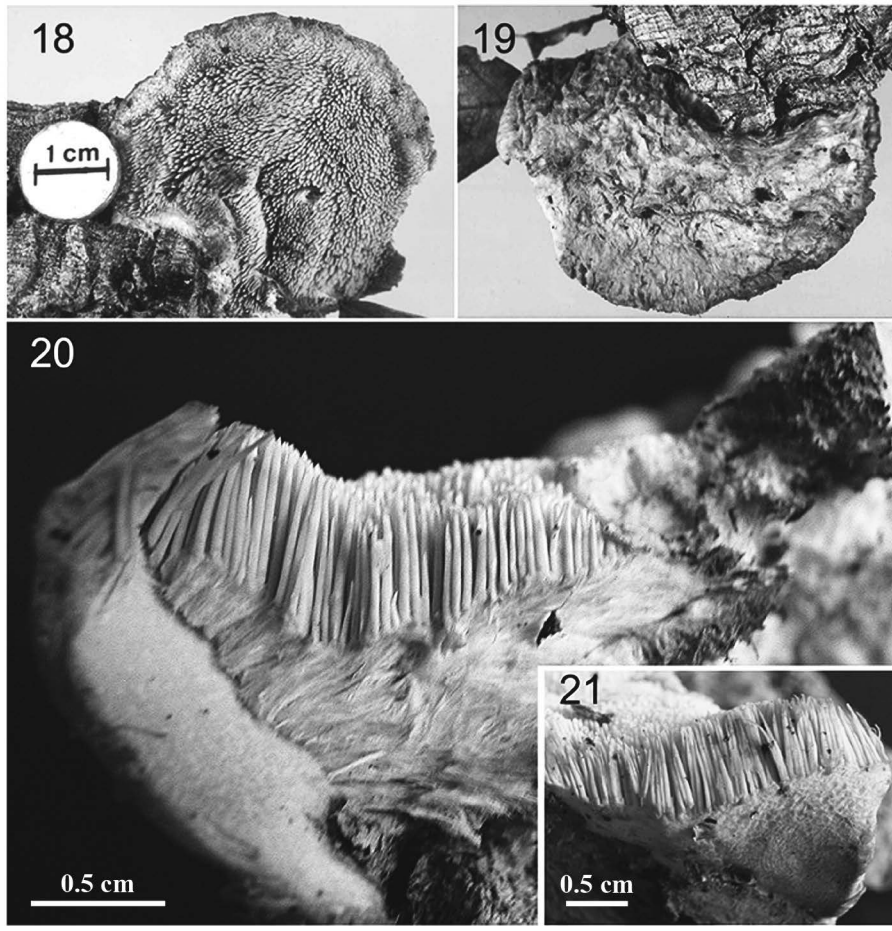
The type material of *Hydnum pulcherrimum* Berk. & M.A. Curtis is conserved inside of a brown envelope, that is kept in a brownish pack labelled as K(M) 135348 (Fig. 12-13). This material consists of remains of a basidioma




Figs. 12-17 *Hydnum pulcherrimum* Type. 12. Label of the herbarium K. 13. Detail of writing. 14. Basidioma. 15. Detail of the trama and the hydnoid hymenophore. 16-17. Multiclamped hyphae of the pileipellis.

fragmented in three portions (Fig. 14). The smallest portion is affixed to a pasteboard and it is possible to observe the hydnoid hymenophore in it (Fig. 15). The second portion is crushed, of approx. 2.5 × 1.5 cm and the largest is approx 5 × 3 cm and is also crushed.

**Description**. – Basidioma strawy cream coloured, fibrous; hymenophore hydnoid, teeth orangish brown, approx. 2 mm long. Hyphal system monomitic. Hyphae of the pileipellis hyaline, septate, double walled, 7-10 µm diam., 1-2-3-4 clamp connections in each septum or rarely afibulate (Figs. 16-17). Hymenophore




Figs. 18-21 *Climacodon pulcherrimu*s. 18-19 Detail of basidioma from Andalusia (Spain), AH 31739. 20. Detail contexto, trama and hidnoid hymenophore, AH 31805. 21. Detail acute ends, AH 31805.

composed by very collapsed hyphae, difficult to see in ammoniac Congo red solution and KOH 5%. Hyphae of the trama of the teeth cylindrical and narrow, 2.5-4 µm diam. Spores hyaline, small and very collapsed, making it difficult to observe their morphology and size.

The type material of *Hydnum duriusculum* from Singapore is conserved in BPI US0324672 (type), in the same packet there is another collection with number BPI US0324671. Both collections are in a bad condition, due to the treatment with mercury chloride and it has been impossible to do the macro and microscopic study. This problem has already been indicated by Maas Geesteranus in a revision label dated to 1969. Only in BPI US0324672, labelled as type, we have been able to see the hydnoid aspect of the hymenophore.

## DISCUSSION

This species is characterized by the dimidiate basidiocarp, irpicoid, with orange tint, hyphae of the pileipelllis and the trama with 2-3-4 clamps, many oil drops in the trama of the hymenophore, lacking cystidia, although sometimes it is possible to observe some hyphal ends in the hymenium and small and hyaline spores (4-5 × 1.5-2 µm), ellipsoid to allantoid.

In the point 9 of the key of the monograph of Maas Geesteranus (1971) on the hydnaceous fungi, the presence of cystidia points to *Climacodon*, but in the description of *Climacodon pulcherrimum* (p. 140) the following description is given: "Gloeocystidia 2.7-4.5 µm wide, projecting but little beyond the basidia, thin-walled to thick-walled, not encrusted, sometimes not developed". In our observations, we have seen no cystidia, neither in type material of *Hydnum pulcherrimum* and due to this fact, it is very difficult to determine *Climacodon pulcherrimum* using this paper.

The genus *Climacodon* was created by Karsten (1881) based in the type species *Hydnum septentrionale* Fr., which has thick-walled cystidia, often with encrusted tips and hyphae, never with more than one clamp connections per septum (Maas Geesteranus, 1971).

Pilát (1933) recombined *Hydnum pulcherrimum* to *Dryodon pulcherrimum* and described the material collected from Siberia on *Fagus sylvatica*, *Betula verrucosa*, *Abies sibirica* and *Populus tremula*, with thin-walled and cylindrical cystidia (38-35 × 3-3.5 µm) projecting 15 µm above the hymenium. We have not observed these cystidia in the Iberian material and nothing in the type of *Hydnum pulcherrimum*. This author does not comment on the presence or absence of clamp connections.

Later Pilát (1936) created the genus *Donkia* for this species with the following latin diagnosis "*Genus ex affinitate generis Dryodon a quo deficientia gloeocystidarum in hymenio membranaque sporarum haud amyloidea discrepat. Inter genera Mycoleptodon et Dryodon genus intermedium. Carposomata effusoreflexa vel laterilater adnata, lignicola, in latere inferiori aculeos ferentia. Hymenium solum e basidiis compositum vel solum cystidiola basidiformia, plus minus vacua adsunt. Sporae hyalinae, ovatae vel ellipsoideae, membrana laevi vi solutionis jodi haud coerulescenti instructae*". As it is possible to see, Pilát described the presence of cystidia basidiformia, absence of gloeocystidia and he did not indicate the presence of clamp connections. We agree with Pilát in the absence of gloeocystidia in the material revised by us, however we have not observed cystidia basidiformia drawn and described by him.

Nakasone (1990) treats this species as *Donkia pulcherrima* and has made cultures with material collected on diverse species of *Quercus* (*Q. virginiana*, *Q. nigra*, *Q. phellos*, *Q. sp.*) and *Abies* sp. from different states of U.S.A. In this paper, the morphological characters are described and he stressed the white rot character, as previously commented by Gilbertson *et al.* (1975). Nakasone indicates that culturally *D. pulcherrima* resembles some *Phanerochaete* P. Karst. species and he mentions the presence of double or multiple clamp connections in the mycelia of the cultures, as also occurs in *P. burtii* (Romell ex Burt) Parmasto, *P. crassa* (Lév.) Burds., *P. ericina* (Bourdot) J. Erikss. & Ryvarden (now *Peniophora ericina*), *P. exilis* (Burt) Burds., *P. flavidoalba* (Cooke) S.S. Rattan, *P. gigantea* (Fr.) S.S. Rattan (now *Phlebiopsis gigantea*), *P. laevis* (Fr.) J. Erikss. & Ryvarden, *P. rimosa* (Cooke) Burds. (now *Scopuloides rimosa*). Burdsall (1985)

cites 13 species of *Phanerochaete* whose subicular hyphae have double or multiple clamp connections.

We sent a portion of the Iberian material before placing it in *Climacodon pulcherrimus*, to Dr. Larsson to do molecular biology studies. He answered us (com. pers.): "the most similar sequences from our dataset represent monomitic, non-clamped species like *Phanerochaete* spp. and *Phlebia deflectens*. It points in a certain direction but does not give enough guidance for a decision about generic placement".

We conclude that the insertion of *Climacodon pulcherrimus* in this genus is inappropriate, due to the presence (only in this species of *Climacodon*) of hyphae with double or multiple clamp connections and the absence of cystidia in the studied material. Also, this species share cultural and molecular characteristics with the genus *Phanerochaete*, so perhaps it must be placed again in the genus *Donkia* or included in the genus *Phanerochaete.*

Other closely related genera are *Odonticium* and *Spongipellis*.

*Odonticium* differs because of its resupinate basidiocarps and the total absence of fibulae, but shares the type of hymenophore with teeth that are fused at the base, absence of cystidia and basidiospores of small dimensions.

*Spongipellis* has dimidiate fructifications with pores. An exception is *S. pachyodon* (Pers.) Kotl. & Pouz., that has a hydnoid hymenophore. However, it differs because one of the characters of the genus is the presence of fibulae in all the septae.

*Climacodon pulcherrimus* has a tropical distribution, it is known from Asia: Japan, Java, Pakistan, Peninsula Malaysia, Philippines, Sikkim and Thailand (Pilát, 1936; Maas Geesteranus, 1971). In Europe it is known only from France (Candousseau, 1981) and Russia (Pilát, 1933, 1936) and recently from Nothern Spain (Salcedo *et al.*, 2006). In America it has been cited by Bononi (1979) and Gibertoni *et al*. (2004) from Brazil, but they indicate the presence of gloeocystidia, dimitic hyphal structure and mention nothing about hyphae having multiple clamp connections in the pileipellis. We have revised this material and find it to be monomitic, and find that it has fibulae only in the generative hyphae with 2-3-4 clamps in the context.

Nakasone (1990) and Gilbertson *et al.* (1975) cited this species from U.S.A.

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