

# THE GENUS *LAETIPORUS* IN NORTH AMERICA

HAROLD H. BURDSALL, JR.<sup>1</sup> AND MARK T. BANIK<sup>1</sup>

**Abstract.** The taxonomy of genus *Laetiporus* in North America is discussed in terms of the species recognized to date. Morphological and ecological characteristics are provided that support the delimitation of three new species, *L. conifericola*, *L. huroniensis*, and *L. gilbertsonii*, and one variety, *L. gilbertsonii* var. *pallidus* that were suggested by molecular and incompatibility data in earlier studies of the genus. A key to the North American species is provided.

**Keywords:** biosystematics, *Laetiporus*, new species, taxonomy.

The genus *Laetiporus* Murrill (1904, p. 607) is well known in North America as represented by the common species *Laetiporus sulphureus* (Bull.: Fr.) Murrill (1920, p. 11). It is associated with a brown rot of wood, occurring in the roots, butt, or heartwood of living trees, but also decaying logs or trunks of trees that have died. *Laetiporus sulphureus* is characterized by sessile to substipitate pilei with an orange upper surface and lemon-yellow pore surface. Peck (1906, p. 34) described a similar fungus as *L. sulphureus* var. *semialbinus* Peck, having a white pore surface. He was apparently unaware that Morgan (1885, p. 97) had described this "variety" as *Polyporus cincinnatus* Morgan. In addition, Rosen (1927, p. 194) described a taxon as *P. sulphureus* var. *overholtsii* H. R. Rosen that seems to be the same taxon as that described by Morgan. However, most later mycologists continued to use Peck's name and concept of the taxon as a variety (Overholts, 1953), if they recognized it at all.

Until recently the morphological similarities confounded those attempting to distinguish taxa within the *L. sulphureus* species complex. The constant association of certain morphological and ecological traits, led Banik and others (1998) to examine potential segregates using the molecular techniques of polymerase chain reaction and restriction fragment length polymorphism (RFLP) analysis and mating incom-

patibility confrontations (Banik and Burdsall, 2000). Examination of 116 collections revealed the presence of seven restriction groups (LRGs) with each collection fitting into one group. LRG IV was composed only of collections that fit precisely the morphological taxon called *Polyporus sulphureus* var. *semialbinus* by Peck and *P. cincinnatus* by Morgan. The molecular data indicated that LRG IV was distinct from *Laetiporus sulphureus*, LRG I. However, the differences in morphology, ecology, and molecular make-up are sufficient to recognize the taxon as a species of *Laetiporus*, not a variety of *L. sulphureus*. Because of nomenclatural priority considerations, according to the ICBN Article 11.3 (Greuter et al., 2000), the appropriate name to apply to this taxon is *L. cincinnatus* (Morgan) Burds., Banik & Volk (Banik et al., 1998, p. 13).

In later work Banik and Burdsall (1999) demonstrated that the seven LRGs were associated consistently with specific *Laetiporus* incompatibility groups (LIGs). Each LIG was intra-LRG-group compatible and inter-LRG-group incompatible, except for LIG I (= *L. sulphureus* ss.), which was associated with three LRGs (Table 1). Interpretation of the data derived from LRG/LIG results indicate that there may be five or six species, including *L. sulphureus* and *L. cincinnatus* present in North America. This result led to the research

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reported here, where an attempt is made to determine whether there are distinctive morphological and ecological characteristics correlated with the LRG/LIG groups that will serve to distinguish other *Laetiporus* species in North America. *Laetiporus persicinus* (Berk. & M. A. Curtis) Gilb. (1981, p. 385) is an additional

species in North America and is treated here. It is not one that would be confused morphologically with species of the "*L. sulphureus* group" and, in fact, our molecular studies indicate it is only distantly related to the "*L. sulphureus* species complex" and may require a new generic disposition (unpublished data).

TABLE 1. Comparison of diagnostic characters of *Laetiporus* species of North America.

| <i>Laetiporus</i>                        | LRG <sup>a</sup> | LIG <sup>b</sup>  | Habit                                   | Pore color  | Distribution            |
|--|------------------|-------------------|---|-------------|-------------------------|
| <i>cinnatus</i>                          | IV               | IV                | Soil near hardwood, esp. <i>Quercus</i> | White       | Eastern, Midwestern USA |
| <i>conifericola</i>                      | III              | III               | Conifer                                 | Yellow      | Western North America   |
| <i>gilbertsonii</i>                      | II               | II                | <i>Quercus</i> , <i>Eucalyptus</i>      | Yellow      | Western North America   |
| <i>gilbertsonii</i> var. <i>pallidus</i> | II               | II                | <i>Quercus</i> , <i>Eucalyptus</i>      | White       | Southern USA            |
| <i>huroniensis</i>                       | IIIa             | IIIa <sup>c</sup> | Conifer                                 | Yellow      | Great Lakes USA         |
| <i>persicinus</i>                        | Not designated   | Not designated    | Conifer, Hardwood                       | Pinkish tan | Southern USA            |
| <i>sulphureus</i>                        | I, VI, VII       | I, VI, VII        | Hardwood, esp. <i>Quercus</i>           | Yellow      | Eastern, Midwestern USA |

<sup>a</sup> *Laetiporus* Restriction Group.  
<sup>b</sup> *Laetiporus* Incompatibility Group.  
<sup>c</sup> Approximately 15% mating compatibility with *L. conifericola*.

#### MATERIALS AND METHODS

Specimens belonging to each LRG/LIG were examined by making a thin hand-section and observing it microscopically mounted in a drop of Melzer's reagent (Hawksworth et al., 1995) or in a drop of 1% aqueous Phloxine B in a drop of 2% aqueous KOH. The observations were

recorded and line drawings made under oil immersion using a Zeiss WL microscope equipped with a drawing tube. Measurements were made of hand sections mounted in Melzer's reagent to avoid the collapse of hyphae that occurs in sections mounted in 2% KOH.

#### GENERIC DESCRIPTION

*Laetiporus* Murrill, Bull. Torrey Bot. Club 31: 607. 1904. TYPE: *Boletus sulphureus* Bull., Herbier France p. 347. pl. 429.1789. (= *Agaricus speciosus* Battarra, Fungorum Agri Arminensis Historia p. 68, pl. 34, f. B. 1855. *Boletus citrinus* Planer, Ind. Plant. Erf., p. 26. 1788. *Polyporus sulphureus* Fr., Syst. Mycol. 1: 357. 1821. *Polypilus sulphureus* P. Karst., Revue Mycol. 3: 17. 1881. *Polypilus speciosus* Murrill, J. Mycol. 9: 93. 1903).

Basidiomes annual, sessile to more or less flabelliform stipitate, occurring on trunks or logs or as rosettes from buried roots in the soil, soft and fleshy when fresh, white, chalky and friable in age; pileus surface orange to salmon-colored, darker when bruised, smooth; pore

surface lemon-yellow to cream-colored or pinkish cream; pores regular, 3-4 mm, up to 5 mm long; context pale yellow to avellaneous or with a pink tint, sometimes with darker reddish brown zonations parallel to the margin; hyphal system dimitic; binding hyphae of broad long cells giving rise to the much branched lateral processes, thick-walled, collapsing in 2% KOH; generative hyphae broad, simple septate, thin to somewhat thickened walls, not collapsing in 2% KOH; cystidia lacking; basidia pyriform, 4-sterigmate, simple septate at base; basidiospores ovoid to broadly ovoid, hyaline, thin-walled, smooth, negative in Melzer's reagent; causing a brown-rot of hardwoods or conifers.

KEY TO THE TAXA OF *LAETIPORUS* IN NORTH AMERICA

- 1a. Basidiome usually some shade of brown to dark brown, excentrically stipitate or in a rosette at base of hardwood or conifer substrates in the southeastern United States, also occurring in Puerto Rico . . . . . *L. persicinus*
- 1b. Basidiome light or bright colored, usually orange, pink, or yellow. . . . . 2
- 2a. Basidiome sessile, imbricate, arising from trunks of standing trees or snags, or on fallen logs, pore surface white to lemon-yellow. . . . . 3
- 2b. Basidiome a rosette arising from soil or surface of a root near the base of a living tree (usually *Quercus*), pore surface cream color to nearly white. . . . . *L. cincinnatus*
- 3a. Basidiome forming only on conifer species. . . . . 4
- 3b. Basidiome forming on hardwood species (usually *Quercus* or *Eucalyptus*). . . . . 5.
- 4a. Distributed in eastern North America on mature conifer species, basidiospores  $5.0-7.0 \times 4.2-5.0 \mu\text{m}$ . . . . . *L. huroniensis*
- 4b. Distributed in far western North America on mature conifer, basidiospores  $6.5-8.0 \times 4.0-5.0 \mu\text{m}$ . . . . . *L. conifericola*
- 5a. Pileus shelving, pale salmon or tan to nearly white, pore surface cream colored or white, on hardwoods (especially *Quercus* and *Eucalyptus*), in states of the USA bordering the Gulf of Mexico. . . . . *L. gilbertsonii* var. *pallidus*
- 5b. Pileus shelving, bright orange, pore surface lemon-yellow, mostly on *Quercus* or *Eucalyptus* in the eastern or southwestern USA. . . . . 6
- 6a. Occurring on hardwoods (especially *Quercus* and *Eucalyptus*), in states of the United States bordering Mexico and the Pacific Ocean. . . . . *L. gilbertsonii*
- 6b. Occurring on hardwoods (especially *Quercus*) in temperate parts of the eastern United States, basidiospores,  $5.5-7 \times (3.5-4-5 \mu\text{m})$ . . . . . *L. sulphureus*

## SPECIES DESCRIPTIONS

*Laetiporus cincinnatus* (Morgan) Burds., Banik & Volk, Folio Cryptog. Estonica 33: 13. 1998. TYPE: UNITED STATES. Ohio: Vicinity of Cincinnati (Mt. Healthy?). The holotype specimen has not been found. A search is in progress for a neotype. Figs. 1-4.

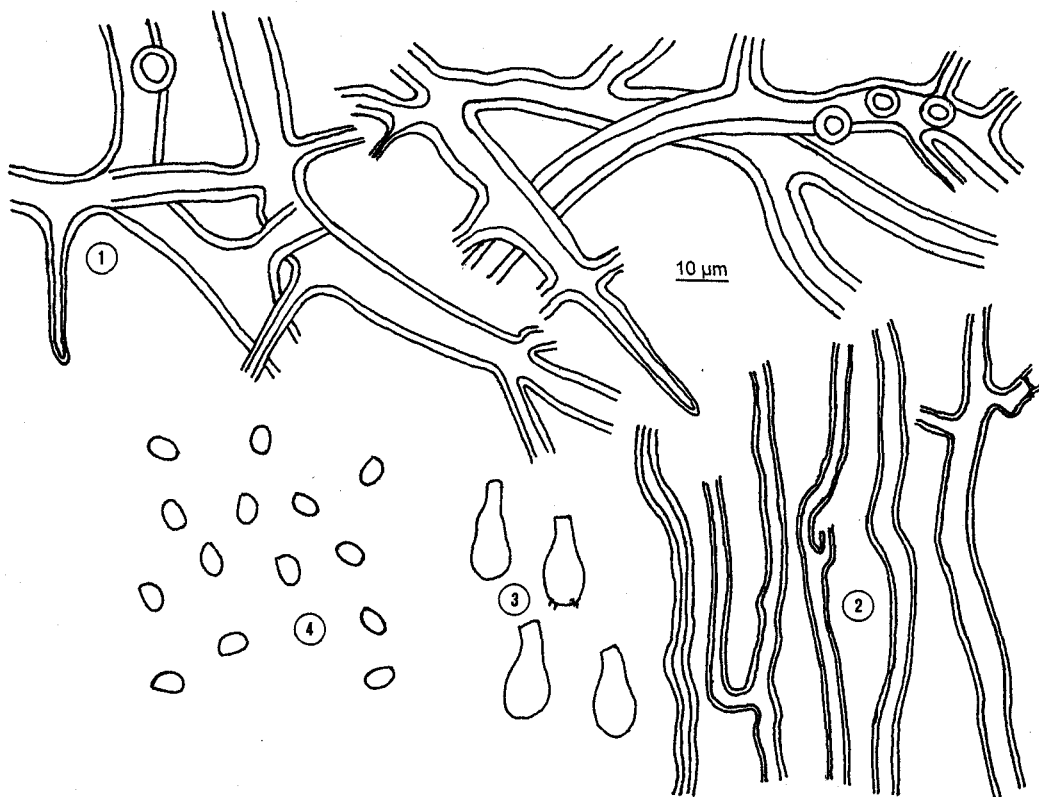
Basidiomes arising from the soil as a rosette up to 45(-60) cm diam, rarely as a small shelf from a tree trunk, stipitate with numerous large flabelliform pilei up to 15 cm wide, 10 cm deep and 3 cm thick, with broad stipe attachment to central stipe column, upper surface of pileus and stipe bright salmon orange; context pale yellow, up to 3 cm thick, sometimes thicker at the central stipe attachment; pore surface pale cream-color, decurrent on the individual stipe attachments; pores 1-5 mm long, 2-4 per mm, nearly circular at first, becoming more angular in age. In soil is the columnar mycelial aggregation from which the stipe is formed and attached to a buried root.

Pileus surface a turf-like layer of erect hyphae, 4.5-6  $\mu\text{m}$  diam, hyaline, thin-walled, smooth, simple septate, arising directly from the context hyphae. Context dimitic, of generative and binding hyphae. Generative hyphae rarely apparent in the context, 4-7  $\mu\text{m}$  diam, walls thin or occasionally slightly thickened, hyaline, smooth, septate, lacking clamp con-

nections. Binding hyphae usually broad (8-12  $\mu\text{m}$  diam), nearly cylindrical, hyaline, walls 1-3  $\mu\text{m}$  thick, with thick-walled hyphal branches 4-7  $\mu\text{m}$  diam extending laterally and tapered, occasionally septate, lacking clamp connections, dissolving nearly completely in 2% KOH, smooth. Pore trama dimitic, composed of generative and skeletal hyphae with more parallel organization than context. Generative hyphae the most common, parallel in arrangement, 2.5-4.5  $\mu\text{m}$  diam, hyaline, thin-walled, frequently septate, lacking clamp connections, remaining intact in 2% KOH. Skeletal hyphae infrequent, 2.5-3  $\mu\text{m}$  diam, nearly parallel but somewhat sinuous and undulating, rarely septate, lacking clamp connections, walls 1-1.5  $\mu\text{m}$  thick, dissolving nearly completely in 2% KOH. Subhymenium a densely compact tissue; hyphae tightly interwoven, frequently septate, lacking clamp connections, thin walled, hyaline, giving rise to the hymenium elements.

Hymenium a palisade of basidia. Basidia pyriform,  $15 \times 7.5 \mu\text{m}$ , hyaline, thin walled, 4-sterigmate, lacking a basal clamp. Basidiospores broadly ovoid,  $4.5-5.5 \times 3.5-4 \mu\text{m}$ , hyaline, thin walled, smooth, negative in Melzer's reagent.

**Habitat:** *Laetiporus cincinnatus* occurs on



FIGURES 1-4. *Laetiporus cincinnatus*: 1, context of pileus; 2, hyphae of pore trama; 3, basidia; 4, basidiospores. From DA-37. Bar = 10µm.

soil near the base of large old hardwood trees (especially *Quercus* spp.). The range is the same as *L. sulphureus* and the two species are equally common in the Great Lakes region. The indication from a survey of herbarium specimens is that they are equally common throughout much of their range.

**Etymology:** from *Cincinnati*, a city in southwestern Ohio, USA, near the location where the type specimen was collected.

**Representative specimens examined:** UNITED STATES. **Illinois:** White Pine State Forest, 29 September 1996, at base of *Quercus alba* L. (?), IL-51 (CFMR). **New York:** Port Jefferson, Long Island, 26 August 1904, no substrate, holotype of *P. sulphureus* var. *semi-albinus* Peck, C.H. Peck, no number (NYS). **Virginia:** South of Clarendon, 9 September 1934, on *Quercus rubra* L., R. W. Davidson FP 59095 (CFMR). **Wisconsin:** Dane County, Springdale, Sutters Woods, 15 October 1997, DA-37 (CFMR); Dane County, Madison, University of Wisconsin, Picnic Point, 19 September 1990, on soil at base of *Q. alba*, T.

J. Volk FP 102462 (CFMR); Dane County, Fitchburg, Dawley Park, 15 August 1995, at base of *Celtis occidentalis* L., M. T. Banik DA-9 (CFMR); Dane County, Fitchburg, Dawley Park, 19 August 1995, at base of dead *Q. nigra* L., M. T. Banik DA-10 (CFMR); Dane County, Madison, University of Wisconsin, Picnic Point, 29 August 1995, on soil near *Q. velutina* Lam., M. T. Banik DA-13 (CFMR); Dane County, Madison, University of Wisconsin, Picnic Point, 29 August 1995, on soil near *Q. nigra*, M. T. Banik DA-14 (CFMR); Dane County, Madison, University of Wisconsin, Picnic Point, 29 August 1995, on soil near *Q. alba*, M. T. Banik DA-15 (CFMR); Iowa County, Governor Dodge State Park, Pine Bluff Trail, 27 August 1995, at base of *Quercus* sp., R. Rentmeester, HHB 15746 (CFMR); Sauk County, Natural Bridge County Park, 3 September 1995, on soil near *Q. nigra*, T. J. Volk TJV-95-48 (CFMR); Sauk County, Natural Bridge County Park, 3 September 1995, on soil near *Acer saccharum* Marshall and *Q. nigra*, T. J. Volk TJV-95-49 (CFMR);

Dane County, Madison, University of Wisconsin Arboretum, Gallistel Woods, 20 September 1995, at base of *Quercus* sp.(?) tip-up, T. J. Volk TJV-95-60 (CFMR).

**Remarks:** *Laetiporus cincinnatus* is rather distinct among the "*L. sulphureus* group." It is the only species that fruits from the soil (buried roots) and it has a white to pale cream-color pore surface. Basidiospore characters also distinguish *L. cincinnatus* from the others as do the molecular studies, which indicate the distinctiveness of the species by placing it well outside the main cluster of the "*L. sulphureus* group."

Basidiomes arise from an aggregation of mycelium that might be referred to as a pseudorhizomorph because the structure is a loosely organized column of soil and hyphae that attaches to the infected root. Basidiomes are found rarely on trunks or logs of large diameter trees. We have observed its association with a brown rot of roots and the butt of trees up to a height of about five feet (unpublished observation). See *L. sulphureus* for further discussion.

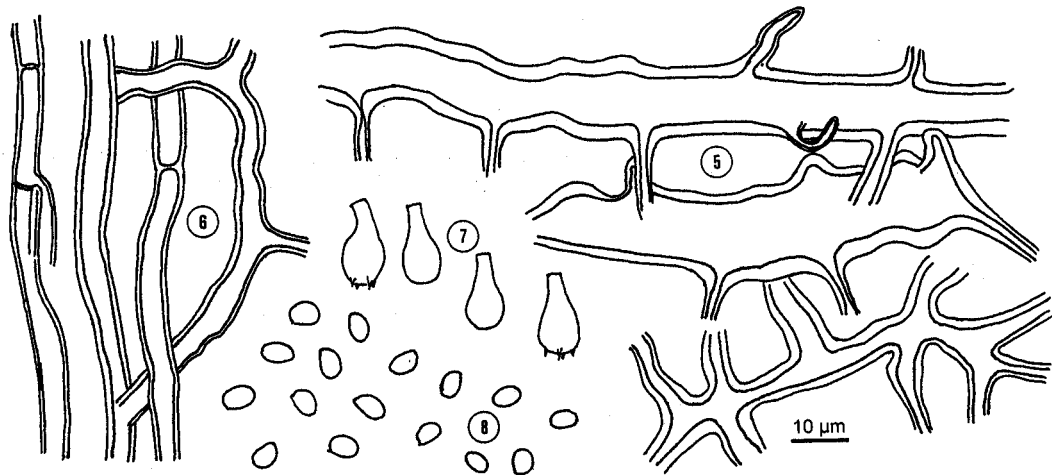
***Laetiporus conifericola*** Burds. & Banik, *sp. nov.* TYPE: UNITED STATES. Alaska: Kenai Peninsula, North of Seward on Seward Highway, Primrose Campground, on 4 ft diam DBH, *Picea × lutzii* Little, 2 October 1999, H. H. Burdsall, Jr. and L. Trummer, HHB 17920 (Holotype: CFMR!). Figs. 5–8.

*Species haec a Laetiporo sulphureo*

*basidiosporis ovoideis, 6.5–8.0 × 4.0–5.0 μm differt. Habitat ad substrato arbores coniferas, in parte Americae Borealis occidentali extrema.*

Basidiomes shelving, dimidiate, up to 25 cm wide, 15 cm deep and 3 cm thick, laterally stipitate, sessile or with broad stipe attachment, upper surface of pileus and stipe bright orange to salmon orange; context pale yellow, up to 2 cm thick, sometimes thicker at the stipe; pore surface lemon yellow to bright creamy yellow; pores 1–5 mm long, 2–4 per mm, nearly circular at first, becoming more angular in age, decurrent on stipe to its attachment.

Pileus surface a tissue of compactly interwoven hyphae 30–50 μm thick; hyphae up to 7 μm diam, but mostly collapsed, walls up to 1 μm thick, hyaline, smooth, septate, lacking clamp connections, grading rather abruptly into pileus context. Pileus context dimitic, composed of binding and generative hyphae. Binding hyphae 4–12 μm diam, mostly long cylindrical hyphae with dendroid side branches, hyaline, smooth, occasionally septate, lacking clamp connections, walls 1–3 μm thick, dissolving nearly completely in 2% KOH. Pore trama dimitic, composed of skeletal and generative hyphae with more parallel organization than in context. Skeletal hyphae, 4–6 μm diam, nearly parallel but somewhat sinuous and undulating, occasionally branched and septate, lacking clamp connections, walls 1–1.5 μm thick, dissolving nearly completely in 2% KOH. Generative hyphae nearly parallel in arrange-



FIGURES 5–8. *Laetiporus conifericola*: 5, context of pileus; 6, hyphae of pore trama; 7, basidia; 8, basidiospores. From HHB 17920, holotype (CFMR). Bar = 10 μm.

merit, 3–5  $\mu\text{m}$ , diam, thin walled, hyaline, regularly septate, lacking clamps, remaining intact in 2% KOH. Subhymenium a densely compact tissue; hyphae tightly interwoven, frequently septate, thin-walled, hyaline, lacking clamps, giving rise to the hymenium elements.

Hymenium of basidia. Basidia pyriform, 15  $\times$  7.5  $\mu\text{m}$ , hyaline, thin walled, 4-sterigmate, lacking a basal clamp. Basidiospores broadly ovoid, 6.5–8.0  $\times$  4.0–5.0  $\mu\text{m}$ , hyaline, thin-walled, smooth, negative in Melzer's reagent.

**Habitat:** *Laetiporus conifericola* occurs on mature and over mature living and dead conifers in western North America from California to Alaska.

**Etymology:** from conifer, the only type of substrate on which this species occurs.

**Representative specimens examined:**  
**CANADA. British Columbia:** Vancouver, Cypress Bowl, 18 August 1994, on dead standing *Abies grandis* (Douglas) Lindl., *H. H. Burdsall, Jr. 15411* (CFMR). **UNITED STATES. Alaska:** Municipality of Anchorage, Girdwood, 20 August 1999, on *Tsuga* sp., *J. Tinius AK-2* (CFMR); Kenai Peninsula, Gold Fin Lake Trail, on *Tsuga* sp., 24 August 1999, *J. Tinius AK-3* (CFMR); Kenai Peninsula, Homer, Beaver Flats, Olson Mt. Road, on dead *Picea* sp., 21 August 1997, *G. Lyon, HHB 17223* (CFMR); Kenai Peninsula, South end Kenai Lake, Primrose Creek Trailhead, on *P.  $\times$  luzii* Little stump, 20 August 1998, *Harold H. Burdsall, Jr. 17601* (CFMR); Ketchikan, on *Tsuga heterophylla* (Raf.) Sarg., 25 July 1998, *J.A.Micales 001* (CFMR); Kenai Peninsula, 10 miles North of Seward on Seward Highway, Gill Fin Trail, on 36" diameter log of *Picea sitchensis* (Bong.) Carrière, 2 October 1999, *H. H. Burdsall, Jr. 17919* (CFMR); Girdwood, Alyeska Ski Resort, on *Picea* sp., 24 August 1996, *P. Kempton 7022 AK-1* (CFMR). **California:** Mendocino County, Jackson State Forest, 24 November 1996, on dead redwood, *D. Rizo CA-8* (CFMR); El Dorado County, Lake Tahoe Basin, on dead *Abies magnifica* A. Murr., 14 September 1998, *D. Rizzo CA-18* (CFMR). **Nevada:** Washoe County, Mt. Rose, Tahoe Rim Trailhead, on living *Pinus contorta* Douglas, 30 September 1998, *H. H. Burdsall, Jr., NV-2* (CFMR). **Idaho:** Halfway House, on *Pinus murrayana* Balf. in Murray, 18 August 1911, *G. G. Hedgcock and J. R. Weir FP 11030* (CFMR); Valley County, Payette National Forest, no substrate, 22 August 1969, *H. M. Shank OKM 8051* (CFMR). **Oregon:** Benton County, Mary's Peak, on *Abies* sp., 8 November 1971, *M. J. Larsen FP 133022*

(CFMR); Lincoln County, near Drift Creek Campground, FS Road 1980, 6 November 1995, on *Picea* sp. or *Tsuga* sp., *J. Roger OR-1* (CFMR). **Washington:** Jefferson County, Olympic National Park, on *T. heterophylla*, 12 October 1998, *T. J. Volk TJV-93-155*(CFMR); Olympic National Park, on *Picea* sp. log, 13 October 1993, *T. J. Volk TJV-93-162*(CFMR); Skyhomish, on *Tsuga* sp., 27 August 1910, *C. J. Humphrey FP 6273* (CFMR).

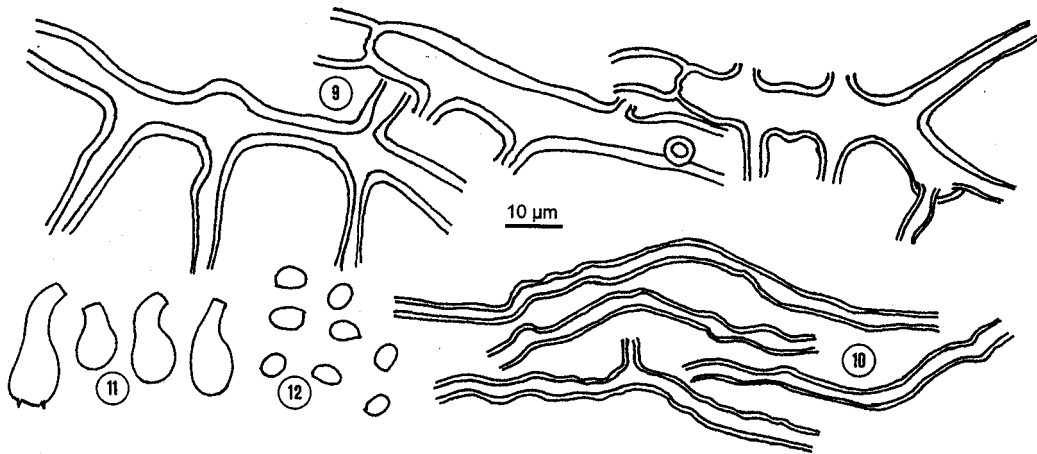
**Remarks:** in western North America *Laetiporus conifericola* is distinguished from the other *Laetiporus* species by occurring on conifers. The only other species of *Laetiporus* in the West is *L. gilbertsonii*, which is found only on hardwoods, mainly *Quercus* and *Eucalyptus* spp. *Laetiporus conifericola* is similar to *L. huroniensis*, which occurs in the Lake States and further east in the northern United States and southern Canada. They differ in basidiospore size and shape and in being about 85% incompatible in incompatibility confrontations as indicated by the isozyme data of the resultant crosses. Morphological interactions of all confrontations in culture plates appear the same as negative readings in other species.

***Laetiporus gilbertsonii* Burds., sp. nov. TYPE:** UNITED STATES. California: San Francisco County, San Francisco, Golden Gate Park, North Pond near 43<sup>rd</sup> Street, on living *Eucalyptus* sp., 26 September 1997, *K. P. Collins, CA-16* (Holotype: CFMR!). Figs. 9–12.

*Species haec a Laetiporo sulphureo basidiomate aurantiaco, pagina poris citrino et basidiosporis 5.0-6.5  $\times$  3.5-4.5  $\mu\text{m}$  differt. Habitat in partibus USA occidentali maritimi.*

Basidiomes shelving, dimidiate, up to 20 cm wide, 15 cm deep and 3 cm thick, laterally stipitate, sessile or with broad stipe attachment, upper surface of pileus and stipe pale salmon orange or pale pinkish orange to tan or light brown in age, sometimes nearly white; context pale yellow to nearly white, up to 2 cm thick, sometimes thicker at the attachment to the substrate; pore surface lemon-yellow to pale lemon-yellow (in the western United States) to isabelline or nearly white (in the southeastern United States); pores 1–5 mm long, 2–4 per mm, nearly circular at first, becoming more angular in age, decurrent on stipe to its attachment.

Pileus surface a tissue of compactly interwoven hyphae 36–50  $\mu\text{m}$  thick. Hyphae up to 5  $\mu\text{m}$  diam, but mostly collapsed, walls up to 1  $\mu\text{m}$ , hyaline, smooth, septate, lacking clamp



FIGURES 9–12. *Laetiporus gilbertsonii*. 9, context of pileus; 10, hyphae of pore trama; 11, basidia; 12, basidiospores. From CA-16, holotype (CFMR). Bar = 10µm.

connections, grading rather abruptly into pileus context. Pileus context dimitic, composed of binding and generative hyphae. Binding hyphae 4–15 µm diam, hyaline, densely branched and intertwined or composed of occasionally septate cylindrical main hyphae with dendroid narrowing branches, lacking clamp connections, walls 1–3 µm thick, dissolving nearly completely in 2% KOH. Generative hyphae 6–10 µm diam, hyaline, thin-walled, smooth, frequently branched and septate, lacking clamp connections. Pore trama dimitic, composed of skeletal and generative hyphae with more parallel organization than context; skeletal hyphae, 4–6 µm diam, nearly parallel but somewhat sinuous and undulating, occasionally septate, lacking clamp connections, walls 1–1.5 µm thick, dissolving nearly completely in 2% KOH. Generative hyphae nearly parallel in arrangement, 3–5 µm diam, thin-walled, hyaline, regularly septate, lacking clamps, remaining intact in 2% KOH. Subhymenium a densely compact tissue; hyphae tightly interwoven, frequently septate, thin-walled, hyaline, lacking clamps, giving rise to the hymenium elements.

Hymenium of basidia. Basidia pyriform, 15 × 7.5 µm, hyaline, thin-walled, 4-sterigmate, lacking a basal clamp. Basidiospores broadly ovoid, 5.0–6.5 × 3.5–4.5 µm, hyaline, thin walled, smooth, negative in Melzer's reagent.

**Habitat:** *Laetiporus gilbertsonii* is associated with a brown rot of *Quercus spp.* and *Eucalyptus spp.*, occurring on living trees or dead trunks and logs. It is reported from the states adjacent to the Mexican border, and north

along the Pacific coast of the United States into the state of Washington.

**Etymology:** in honor of Dr. Robert L. Gilbertson, mycological taxonomist and specialist in the Aphyllophorales, teacher and mentor to young mycologists, and valued colleague of mycologists throughout the world.

**Representative specimens examined:** UNITED STATES. **California:** Santa Cruz County, Santa Cruz, all on *Eucalyptus* stumps, 1 November 1995, *N. Andresen CA-5, CA-6, CA-7* (CFMR); Napa County, St Helena, on living *Quercus* sp., no date, *D. Rizzo CA-13* (CFMR); Contra Costa County, Lafayette, on *Prunus* sp., 13 September 1997, *K. P. Collins CA-15* (CFMR); Marin County, San Rafael, Dominican College, on *Eucalyptus* sp., no date, *K. P. Collins CA-17* (CFMR); Yosemite National Park, Curry Village, on dead *Q. kelloggii* Newb., 25 September 1998, *CA-19* (CFMR). **Oregon:** Klamath County, W. of Grants Pass, on *Quercus garryana* Douglas, 24 October 1909, *G. G. Hedgcock FP1704* (CFMR). **Washington:** on *Prunus* sp., October 1998, *W. Litke WAS-1* (CFMR).

**Remarks:** during the study of this species the possibility that it was *Laetiporus discolor* (Klotzsch) Corner was entertained. *Laetiporus discolor* was described from Maritius and is reported from several tropical locations. Thus, there was a possibility that the nearly subtropical distribution in the southern United States was a northern extreme for the species. Comparing descriptions and several specimens from tropical Africa (the type was not available) convinced us that this was not the case.

*Laetiporus gilbertsonii* Burds. var. *pallidus* Burds., var. nov. TYPE: U.S.A. Florida, Wakulla County, Boneyard, on *Quercus* sp., 2 December 2000, Jonathan Caldwell TJV-2000-101 (Holotype: CFMR!).

*Species haec a Laetiporo gilbertsonii basidiomate pallide aurantiaco vel pallide brunneo vel albido, pagina poris albido et basidiosporis 5.0-6.5 × 3.5-4.5 μm differt. Habitat in partibus USA australi.*

*Laetiporus gilbertsonii* var. *pallidus* differs from var. *gilbertsonii* only in its pale colors and its distribution. Instead of the bright orange pileus surface and lemon-yellow pore surface found in *L. gilbertsonii* var. *gilbertsonii*, this variety has a pale orange to pink or rosy pileus surface and white or pale cream pore surface. It is found in the states of the USA that border the Gulf of Mexico. Other characteristics including the molecular characters are the same as found in *L. gilbertsonii*, and single spore isolates of the two varieties are compatible.

**Habitat:** This variety occurs as a brown rot of living and dead *Quercus* spp. and *Eucalyptus* spp. It is distributed from Florida west across the states bordering the Gulf of Mexico.

**Etymology:** from pale = pallid, because of the diagnostic characteristic of having a pale orange to pale brown pileus surface and a white pore surface.

**Representative specimens examined:** PUERTO RICO. Luquillo: Caribbean National Forest, LaMina Recreation Area, on hardwood tree stump, 13 November 1991, D. J. Lodge and S. Cantrell PR-2793 (CFMR). UNITED STATES. **Louisiana:** Orleans Parrish, New Orleans, on living *Q. virginiana* Mill., 3 December 1990, T. J. Volk FP 102571 (CFMR); Jefferson Parrish, Bayou Coquille, on *Quercus* sp. or *Acer* sp., 4 December 1995, T. J. Volk TJV-95-106, TJV-95-107 (CFMR); Jefferson Parrish, Bayou Coquille, on *Q. virginiana*, 4 December 1995, T. J. Volk TJV-95-108 (CFMR). **Texas:** Travis County, Austin, on *Q. virginiana*, 17 November 1911, W. H. Long FP 12878 (CFMR); Travis County, Austin, on *Q. virginiana*, 30 October 1915, W. H. Long FP 21051 (CFMR)

**Remarks:** we have not been able to explain the fact that the pore color in this species differs in the specimens found in the southeastern United States versus those in the western part of the country. In all other respects studied—habitat, ecology, morphology, and molecular characters—the white pored and the yellow

pored specimens and cultures are identical and they are completely compatible in haploid confrontations. The situation in this species may be similar to that seen in the two types of *L. sulphureus* (see under *L. sulphureus* below). This may be the result of some slight difference in the genetic make-up at the pore color gene, possibly a recessive expression. Such a case is seen with *Panellus stypticus* (Bull.:Fr.) P. Karst., in which the European populations are non-luminescent and the North American population is luminescent. However, they are otherwise morphologically identical and completely compatible. Crossing a luminescent North American haploid isolate with a non-luminescent European haploid results in a luminescent dikaryon.

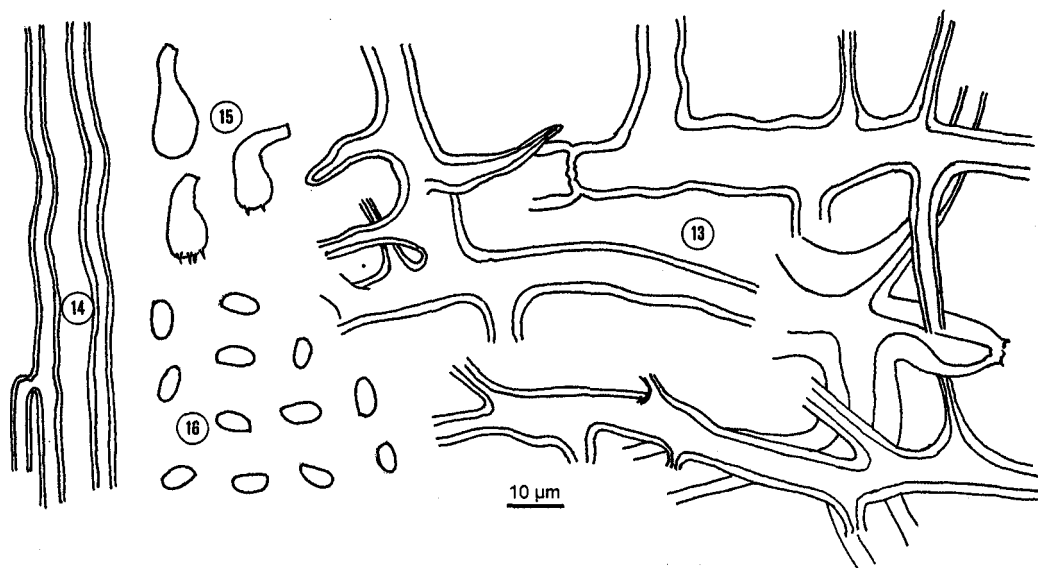
*Laetiporus huroniensis* Burds. & Banik, sp. nov. TYPE: UNITED STATES. **Michigan:** Gogebic County, Ottawa National Forest, Sylvania Wilderness Area, on *Tsuga canadensis* (L.) Carrière, 8 September 1999, D. Czederpiltz, MI-14 (Holotype: CFMR!). Figs. 13–16.

*Species haec a Laetiporo sulphureo, basidiosporis late ovoideis, 5.0-7.0 × 4.2-5.0 μm. Habitat ad substrato ardores coniferas in partibus Americae Borealis orientalis atque "Great Lakes" dicto.*

Basidiomes shelving, dimidiate, up to 25 cm wide, 15 cm deep and 3 cm thick, laterally stipitate, sessile or with broad stipe attachment, upper surface of pileus and stipe bright orange; context pale yellow, up to 3 cm thick, sometimes thicker at the stipe; pore surface lemon yellow to bright creamy yellow in age, pores 1–5 mm long, 2–4 per mm nearly circular at first, becoming more angular in age, decurrent on stipe to its attachment.

Pileus surface a tissue of compactly interwoven hyphae 30–50 μm thick. Hyphae up to 7 μm diam, but mostly collapsed, walls up to 1 μm, hyaline, smooth, septate, lacking clamp connections, grading rather abruptly into pileus context. Pileus context dimitic, composed of binding and generative hyphae. Binding hyphae 4–12 μm diam, hyaline, occasionally septate, lacking clamp connections, walls 1–3 μm thick, dissolving nearly completely in 2% KOH. Generative hyphae rarely apparent in the context. Pore trama dimitic, composed of skeletal and generative hyphae with more parallel organization than context. Skeletal hyphae 4–6 μm diam, nearly parallel but somewhat sinuous and





FIGURES 13–16. *Laetiporus huroniensis*. 13, context of pileus; 14, hyphae of pore trama; 15, basidia; 16, basidiospores. From MI-14, holotype (CFMR). Bar = 10µm.

undulating, occasionally septate, lacking clamp connections, walls 1–1.5 µm thick, dissolving nearly completely in 2% KOH. Generative hyphae nearly parallel in arrangement, 3–5 µm, diam, thin walled, hyaline, regularly septate, lacking clamps, remaining intact in 2% KOH. Subhymenium a densely compact tissue. Hyphae tightly interwoven, frequently septate, thin walled, hyaline, septate, lacking clamps, giving rise to the hymenium elements.

Hymenium of basidia. Basidia pyriform, 15 x 7.5 µm, hyaline, thin-walled, 4-sterigmate, lacking a basal clamp. Basidiospores broadly ovoid, 5.0–7.0 x 4.2–5.0 µm, hyaline, thin walled, smooth, negative in Melzer's reagent.

**Habitat:** *Laetiporus huroniensis* occurs on mature and over mature conifers in eastern North America and in its Great Lakes area. It is known only from the Upper Peninsula of Michigan and Wisconsin, but almost certainly occurs in adjacent areas and to the east on old growth conifers.

**Etymology:** from Huron, as in the Huron Mountains in the Upper Peninsula of Michigan, USA, one of the locations where this species is found commonly, + ensis, indicating place of origin. = huroniensis.

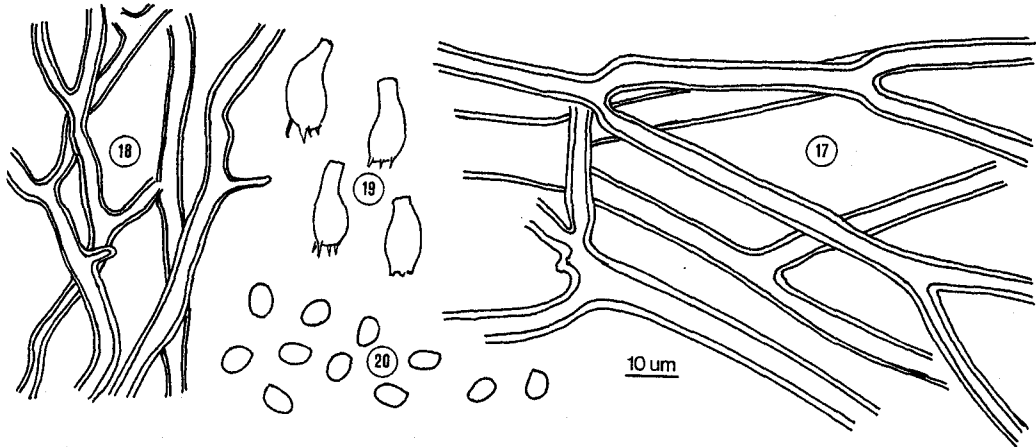
**Representative specimens examined:** UNITED STATES. **Michigan:** Gogebie County, Sylvania National Wildlife Area, Loon Lake, on dead *T. canadensis*, no date, *D. Linder CMI-4* (CFMR); Gogebie County, Sylvania National Wildlife Area, on dead *T. canadensis*,

1996(?), *J. Martin VI-9* (CFMR); Marquette County, Huron Mountains, on *T. canadensis* log, 29 August 1998, *D. Richter MI-7* (CFMR); Marquette County, Big Bay, Huron Mountains, Huron Mountain Club, road at 3<sup>rd</sup> Pine Lake access, on *T. canadensis* log, 6 July 1999, *M. T. Banik HMC-1* (CFMR); Marquette County, Big Bay, Huron Mountains, Huron Mountain Club, road at 3<sup>rd</sup> Pine Lake access, on *T. canadensis* log, no date (1999?), *M. T. Banik HMC-2* (CFMR).

**Remarks:** In northeastern and in north central United States *Laetiporus huroniensis* is distinguished from other *Laetiporus* spp. by its occurrence on old large diameter conifers. The only other species of *Laetiporus* in the area that might be confused with *L. huroniensis* is *L. sulphureus*, which occurs on hardwoods, mainly *Quercus*. *Laetiporus huroniensis* is similar to *L. conifericola*, which occurs in the western United States and Canada on mature conifers from California and Nevada to south central Alaska. They also differ in spores size and shape, in being about 85% incompatible in incompatibility confrontations, and in glucose-6-isomerase phenotype, culture morphology and DNA sequence.

*Laetiporus persicinus* (Berk. & M. A. Curtis) Gilb., Mycotaxon 12: 372–416. 1981. Figs. 17–20.

Basidiomes annual, centrally or excentrically stipitate, with a single pileus or several arising



FIGURES 17–20. *Laetiporus persicinus*. 17, context of pileus; 18, hyphae of pore trama; 19, basidia; 20, basidiospores. From HHB 9668 (CFMR). Bar = 10 µm.

from a central stipe, sometimes a rosette as with *L. cincinnatus*, up to 30 cm diam; upper surface of pileus light to dark brown (sometimes with a pink tint, fide Gilbertson, 1981), finely tomentose to hispid, slightly zonate in some specimens; stipe simple or branched, up to 10 cm long and 4–5 cm thick; context pale tan to pinkish tan, up to 2 cm thick, sometimes thicker at the stipe; pore surface pinkish tan to creamy tan, decurrent onto upper portions of the stipe, pores up to 10 mm long, 3–4 per mm, nearly circular at first, becoming more angular in age.

Hyphal system dimitic. Pileus surface a tissue of compactly interwoven hyphae 30–50 µm thick. Hyphae up to 5 µm diam, but mostly collapsed, walls up to 1 µm, hyaline, smooth, septate, lacking clamp connections, grading rather abruptly into pileus context. Pileus context dimitic, composed of binding and generative hyphae; binding hyphae 5–10 µm diam, dendritically branched, hyaline, occasionally septate, lacking clamp connections, walls 1–3 µm thick, dissolving almost completely in 2% KOH; generative hyphae 7–18 µm diam, some with somewhat granular contents appearing as gloeopleurous hyphae, hyaline, thin-walled, smooth; pore trama dimitic, composed of skeletal and generative hyphae with more parallel organization than context. Skeletal hyphae, 4–6 µm diam, nearly parallel but somewhat sinuous and undulating, occasionally septate, lacking clamp connections, walls 1–1.5 µm thick, dissolving nearly completely in 2% KOH. Generative hyphae nearly parallel in arrange-

ment, 3–5 µm, diam, thin walled, hyaline, regularly septate, lacking clamps, remaining intact in 2% KOH, some also up to 8 µm diam and containing granular content much like gloeopleurous hyphae. Subhymenium a densely compact tissue. Hyphae tightly interwoven, frequently septate, thin walled, hyaline, septate, lacking clamps, giving rise to the hymenium elements. Hymenium of basidia. Basidia clavate, 25–30 × 8–10 µm, hyaline, thin-walled, 4-sterigmate, lacking a basal clamp. Basidiospores broadly ovoid, 6.5–8.0 × 4.0–5.0 µm, hyaline, thin-walled, smooth, negative in Melzer's reagent.

**Habitat:** *Laetiporus persicinus* occurs as a root-rot on living hardwoods (especially *Quercus* spp.) and *Pinus* spp. in the southeastern United States. It also occurs in Puerto Rico on hardwood species.

**Representative specimens examined:** PUERTO RICO. Caribbean National Forest, El Verde Research Area, on base of *Buchenavia capitata* Eichl., 25 January 1998, D. J. Lodge PR-5094 (CFMR); Rio Sonadora, on *Inga vera* Willd., August 1984, D. J. Lodge no number (CFMR). UNITED STATES. **Arkansas:** Ashley County, Hamburg, on ground, 5 October 1955, P. Lentz FP 106574 (CFMR). **Florida:** Leon County, Tall Timbers Research Station, Instruction Field, on *Pinus taeda* L., 26 July 1977, H. H. Burdsall, Jr. 9564 (CFMR); Leon County, Tall Timbers Research Station, Sheep Island, at base of living *Quercus virginiana*, 31 July 1977, H. H. Burdsall, Jr. 9668 (CFMR);

Alachua County, Windsor, on *Q. virginiana*, 1 September 1952, A. S. Rhoads FP 64662 (CFMR); Alachua County, Gainesville, Magnesium Springs, on *Q. laurifolia* Michx., 4 September 1952, A. S. Rhoads FP 103122 (CFMR). **Louisiana:** E. Baton Rouge Parrish, Baton Rouge, College Town Subdivision, on *Q. virginiana*, 2 July 1983, R.L. Gilbertson 14725 (CFMR). **Maryland:** Prince Georges County, Laurel, Patuxant Wildlife Refuge, unknown substrate, 12 August 1966, A. L. Welden JLL 14292, OKM 4672 (CFMR).

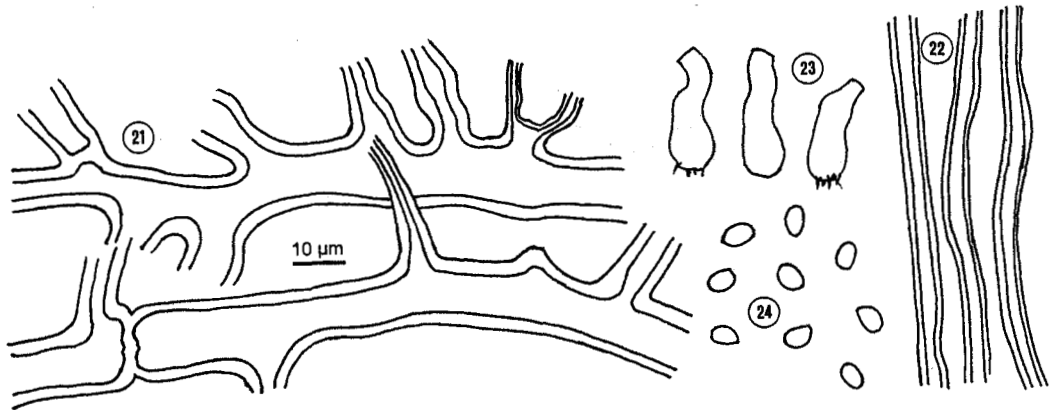
**Remarks:** *Laetiporus persicinus* differs substantially from the rest of the species in the genus. It is more darkly pigmented and the binding hyphae do not have the appearance of the other species. In addition, the molecular studies place *L. persicinus* even more distantly from the *L. sulphureus* complex than such other brown-rot species as *Phaeolus schweinitzii* (Fr.) Pat. Additional studies of this species may require that it be placed in a different genus.

*Laetiporus sulphureus* (Bull.:Fr.) Murrill, *Mycologia* 12: 1 l. 1920. Figs. 21–24.

Basidiomes shelving, dimidiate, up to 45 cm wide, 30 cm deep and 3 cm thick, laterally stipitate, sessile or with broad stipe attachment, upper surface of pileus and stipe bright salmon orange; context pale yellow, up to 3 cm thick, sometimes thicker at the stipe; pore surface lemon yellow to bright creamy yellow, 1–5 mm long, 2–4 per mm nearly circular at first, becoming more angular in age, decurrent on stipe to its attachment.

Pileus surface a tissue of compactly interwoven hyphae 30–50  $\mu\text{m}$  thick. Hyphae up to 7  $\mu\text{m}$  diam, but mostly collapsed, walls up to 1  $\mu\text{m}$ , hyaline, smooth, septate, lacking clamp connections, grading rather abruptly into pileus context. Pileus context dimitic, composed of binding and generative hyphae. Binding hyphae 4–12  $\mu\text{m}$  diam, hyaline, occasionally septate, lacking clamp connections, walls 1–3  $\mu\text{m}$  thick, dissolving nearly completely in 2% KOH. Generative hyphae rarely apparent in the context. Pore trama dimitic, composed of skeletal and generative hyphae with more parallel organization than context. Skeletal hyphae, 4–6  $\mu\text{m}$  diam, nearly parallel but somewhat sinuous and undulating, occasionally septate, lacking clamp connections, walls 1–1.5  $\mu\text{m}$  thick, dissolving nearly completely in 2% KOH. Generative hyphae nearly parallel in arrangement, 3–5  $\mu\text{m}$ , diam, thin walled, hyaline, regularly septate, lacking clamps, remaining intact in 2% KOH. Subhymenium a densely compact tissue; hyphae tightly interwoven, frequently septate, thin walled, hyaline, septate, lacking clamps, giving rise to the hymenium elements. Hymenium of basidia only. Basidia pyriform,  $15 \times 7.5 \mu\text{m}$ , hyaline, thin walled, 4-sterigmate, lacking a basal clamp. Basidiospores broadly ovoid,  $5.5\text{--}7 \times (3.5\text{--})4\text{--}5 \mu\text{m}$ , hyaline, thin walled, smooth, negative in Melzer's reagent.

**Habitat:** *Laetiporus sulphureus* occurs as a brown heart-rot of hardwood species (especially *Quercus* spp.) throughout the eastern USA except for in the states along the Gulf of



FIGURES 21–24. *Laetiporus sulphureus*. 21, context of pileus; 22, hyphae of pore trama; 23, basidia; 24, basidiospores. From HHB 2686 (CFMR). Bar = 10 $\mu\text{m}$ .

Mexico where *L. gilbertsonii* is common. It fruits as shelving basidiomes on logs and on the trunks of living or dead trees, frequently as much as 10 feet or more above ground level and appears to differ in its function by causing a true heart-rot rather than a root- and butt-rot as caused by *L. cincinnatus*. Our observations indicate that the rot caused by *L. cincinnatus* is found in the roots and butt of the tree up to only 4–5 feet above ground level. The rot caused by *L. sulphureus*, while occurring as low as 3–4 feet in the trunk, is also found much higher in the tree.

**Representative specimens examined:**  
**UNITED STATES. Connecticut:** New London County, Westchester, Salmon River State Forest, Rt. 16, on hardwood (*Quercus?*), 22 September 2000, *G. Davis CT-3* (CFMR); New Haven County, East of New Haven, on *Gleditsia tricanthos* L., August 1936, *C. Hartley FP 71200* (CFMR). **Illinois:** Vermilion County, Forest Glen Preserve, Big Woods Trail, on *Quercus borealis* Michx. log, 30 September 2000, *H. H. Burdsall, Jr. 18793* (CFMR). **Maryland:** Prince Georges County, Laurel, on *Quercus* sp., 27 October 1966, *J. A. Lindsay OKM 4994* (CFMR). **Michigan:** Marquette County, Big Bay, Huron Mountain Club, Mt. Homer, on *Quercus* sp., 31 August 1999, *M. T. Banik HMC-14* (CFMR). **Minnesota:** Dakota County, St. Paul, University Farm on *Quercus macrocarpa* Michx., September 1936, *C. Christensen FP 71287* (CFMR); Beltrami County, Bemidji, on hardwood, 25 August 1995, *T. J. Volk NAMA-2* (CFMR). **New York:** Springwater, on *Q. borealis* (?), 5 September 1932, *P. Spaulding* and *C. Hartley FP 56405* (CFMR); Rockland County, Tallman State Park, on hardwood log (?), 9 October 1995, *G. Sheine NY-1* (CFMR). **New Jersey:** Somerset County, Pottersville, on *Fraxinus nigra* Marshall, 9 October 1995, *S. Hopkins NJ-1* (CFMR). **North Carolina:** Mills Creek, on *Castanea dentata* (Marshall) Borkh., 17 September 1928, *F. H. Kaufert* and *A. W. Chapman FP 48239* (CFMR); Macon County, Highlands, Sagee Mountain, Bowery Rd., on *Quercus* sp. log, 4 August 1969, *Harold H. Burdsall, Jr. 2686* (CFMR). **Wisconsin:** Dane County, Madison, University of Wisconsin, Picnic Point, on *Salix* sp., 8 September 1994, *M. T. Banik DA-7* (CFMR); Dane County, Madison School Forest, on *Quercus nigra* L., 22 September 1995, *M. T. Banik DA-22* (CFMR); Dane County, Madison School Forest, on *Q. velutina*, 22 September 1995, *M.*

*T. Banik DA-23* (CFMR); Dane County, Madison, University of Wisconsin Arboretum, on *Quercus* sp. log, 29 August 1995, *M. T. Banik DAAR-3* (CFMR); Dane County, University of Wisconsin Arboretum, on *Quercus* sp. log, 9 September 1995, *T. J. Volk TJV-95-62* (CFMR); Crawford County, Wydusing State Park, on *Q. nigra*, 26 July 1995, *M. T. Banik GR-9* (CFMR).

**Remarks:** *Laetiporus sulphureus* is of more restricted morphology, habit, and range than previously considered. It always has a sulphur-yellow pore surface and fruits on the trunks of living trees or on dead trunks or logs with *Quercus* spp. as its preferred host/substrate. It occurs in the eastern USA (approximately east of the Mississippi River) from as far north as central Minnesota and New York to the northern parts of the southern states.

One morphological entity in our studies continues to be problematic. It includes rare specimens of a white pored *Laetiporus* that occurs on tree trunks. Except for white pores it is indistinguishable from *L. sulphureus*, in morphology, habit and molecular characteristics. In all characteristics except for the white pores it differs from *L. cincinnatus*. We have been unable to obtain spore germination of this morphotype, so mating incompatibility has been impossible to discern. Attempts to germinate the basidiospores and additional molecular studies will continue in order to establish the true relationship of this entity.

#### DISCUSSION

Similar types of investigations are in progress with regard to the European populations of *Laetiporus* (Rogers et al., 1998, 1999). However, the evidence from those studies was not conclusive as to the specific status of the conifer and hardwood populations. That work is continuing. Cerný (1989, p. 45) described the conifer inhabiting *Laetiporus* species and offered a new name, *L. monticola* Cerný. However, the description was not accompanied by a Latin diagnosis. Thus, the name is not validly published.

Several questions remain to be answered through the investigations of the European *Laetiporus* species. Is the European conifer-inhabiting *Laetiporus* conspecific with one of the North American conifer inhabiting species? Is the North American species called *L. sulphureus* conspecific with *L. sulphureus* of Europe? And are there other taxa in the *L. sulphureus* complex represented in Europe?

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