

**Supplementary Table S1.** Strain information and their accession numbers.

| Isolation | Species                   | Host                       | Source                   | Date       | Accession   |               |
|-----------|---------------------------|----------------------------|--------------------------|------------|-------------|---------------|
|           |                           |                            |                          |            | <i>rpb2</i> | <i>tef1-α</i> |
| JZBQF5    | <i>T. miyunense</i>       | <i>Auricularia heimuer</i> | Beijing, Miyun           | 2020.9.9   | ON649968    | ON649915      |
| JZBQF7    | <i>T. miyunense</i>       | <i>Auricularia heimuer</i> | Beijing, Miyun           | 2020.9.9   | ON649969    | ON649916      |
| JZBQF9    | <i>T. miyunense</i>       | <i>Auricularia heimuer</i> | Beijing, Miyun           | 2020.9.9   | ON649970    | ON649917      |
| JZBQH11   | <i>T. pholiotae</i>       | <i>Pholiota adipose</i>    | Beijing, Haidian         | 2020.9.25  | ON649971    | ON649918      |
| JZBQH12   | <i>T. pholiotae</i>       | <i>Pholiota adipose</i>    | Beijing, Haidian         | 2020.9.25  | ON649972    | ON649919      |
| JZBQH13   | <i>T. pholiotae</i>       | <i>Pholiota adipose</i>    | Beijing, Haidian         | 2020.9.25  | ON649973    | ON649920      |
| JZBQT0Z1  | <i>T. lentinulae</i>      | <i>Lentinula edodes</i>    | Beijing, Haidian         | 2021.8.3   | /           | /             |
| JZBQT0Z2  | <i>T. lentinulae</i>      | <i>Lentinula edodes</i>    | Beijing, Haidian         | 2021.8.3   | /           | /             |
| JZBQT0Z3  | <i>T. lentinulae</i>      | <i>Lentinula edodes</i>    | Beijing, Haidian         | 2021.8.3   | /           | /             |
| JZBQT0Z4  | <i>T. lentinulae</i>      | <i>Lentinula edodes</i>    | Beijing, Haidian         | 2021.8.3   | /           | /             |
| JZBQT1Z7  | <i>T. auriculariae</i>    | <i>Auricularia heimuer</i> | Beijing, Tongzhou        | 2021.8.26  | ON649949    | ON649896      |
| JZBQT1Z8  | <i>T. auriculariae</i>    | <i>Auricularia heimuer</i> | Beijing, Tongzhou        | 2021.8.26  | ON649950    | ON649897      |
| JZBQT1Z9  | <i>T. auriculariae</i>    | <i>Auricularia heimuer</i> | Beijing, Tongzhou        | 2021.8.26  | ON649951    | ON649898      |
| JZBQT2Z1  | <i>T. pleuroti</i>        | <i>Pleurotus ostreatus</i> | Beijing, Fangshan        | 2021.9.23  | /           | /             |
| JZBQT2Z2  | <i>T. pleuroti</i>        | <i>Pleurotus ostreatus</i> | Beijing, Fangshan        | 2021.9.23  | /           | /             |
| JZBQT2Z3  | <i>T. pleuroti</i>        | <i>Pleurotus ostreatus</i> | Beijing, Fangshan        | 2021.9.23  | ON649974    | ON649921      |
| JZBQT2Z4  | <i>T. pleuroti</i>        | <i>Pleurotus ostreatus</i> | Beijing, Fangshan        | 2021.9.23  | ON649975    | ON649922      |
| JZBQT3Z1  | <i>T. pleuroticola</i>    | <i>Pleurotus ostreatus</i> | Beijing, Haidian         | 2021.11.17 | ON649976    | ON649923      |
| JZBQT3Z2  | <i>T. pleuroticola</i>    | <i>Pleurotus ostreatus</i> | Beijing, Haidian         | 2021.11.17 | ON649977    | ON649924      |
| JZBQT7Z1  | <i>T. atroviride</i>      | <i>Lentinula edodes</i>    | Hebei province, Pingquan | 2022.1.1   | ON649980    | ON649927      |
| JZBQT7Z2  | <i>T. atroviride</i>      | <i>Lentinula edodes</i>    | Hebei province, Pingquan | 2022.1.1   | ON649981    | ON649928      |
| JZBQT7Z3  | <i>T. atroviride</i>      | <i>Lentinula edodes</i>    | Hebei province, Pingquan | 2022.1.1   | ON649982    | ON649929      |
| JZBQT7Z4  | <i>T. atroviride</i>      | <i>Lentinula edodes</i>    | Hebei province, Pingquan | 2022.1.1   | /           | /             |
| JZBQT7Z5  | <i>T. atroviride</i>      | <i>Lentinula edodes</i>    | Hebei province, Pingquan | 2022.1.1   | /           | /             |
| JZBQT8Z1  | <i>T. longibrachiatum</i> | <i>Lentinula edodes</i>    | Hebei province, Pingquan | 2022.1.8   | ON649994    | ON649941      |

|            |                           |                         |                          |           |          |          |
|------------|---------------------------|-------------------------|--------------------------|-----------|----------|----------|
| JZBQT8Z2   | <i>T. longibrachiatum</i> | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.1.8  | ON649995 | ON649942 |
| JZBQT8Z3   | <i>T. longibrachiatum</i> | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.1.8  | /        | /        |
| JZBQT8Z4   | <i>T. atroviride</i>      | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.1.8  | ON649983 | ON649930 |
| JZBQT8Z5   | <i>T. atroviride</i>      | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.1.8  | ON649984 | ON649931 |
| JZBQT8Z6   | <i>T. atroviride</i>      | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.1.8  | ON649985 | ON649932 |
| JZBQT10Z1  | <i>T. citrinoviride</i>   | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.2.11 | /        | /        |
| JZBQT10Z2  | <i>T. citrinoviride</i>   | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.2.11 | /        | /        |
| JZBQT10Z3  | <i>T. citrinoviride</i>   | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.2.11 | /        | /        |
| JZBQT10Z4  | <i>T. citrinoviride</i>   | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.2.11 | /        | /        |
| JZBQT10Z9  | <i>T. atroviride</i>      | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.2.11 | ON649989 | ON649936 |
| JZBQT10Z13 | <i>T. atroviride</i>      | <i>Lentinula edodes</i> | Hebei province, Pingquan | 2022.2.11 | ON649990 | ON649937 |
| JZBQL45    | <i>T. longibrachiatum</i> | <i>Lentinula edodes</i> | Henan province, Nanyang  | 2021.4.20 | /        | /        |
| JZBQL46    | <i>T. longibrachiatum</i> | <i>Lentinula edodes</i> | Henan province, Nanyang  | 2021.4.20 | /        | /        |
| JZBQL50    | <i>T. paraviridescens</i> | <i>Lentinula edodes</i> | Henan province, Nanyang  | 2021.4.20 | /        | /        |

Note: “/” indicates that the sequence is not uploaded.

**Supplementary Table S2.** Comparison of the morphological characteristics of *Trichoderma auriculariae* and its relatives.

| Species                | Branching pattern   | Phialides (μm)  | Phialides L/W | Base width of Phialides (μm) | Conidia (μm)  | L/W of Conidia | Chlamydospore (μm)                               | Reference  |
|------------------------|---|---|---------------|------------------------------|---|----------------|--|------------|
| <i>T. auriculariae</i> | Pyramidal, with opposing branches borne on a conspicuously broad spindle, less solitary | Ampulliform, sometime lageniform, 4.6–9.9 × (2.2–)2.7–3.8 | 1.4–3.5(–4.4) | 1.4–2.7                      | Globose or subglobose, sometimes ellipsoidal, 2.7–3.8 × 2.3–3.1 | 1.0–1.3        | Ellipsoide, globose or oblong, 4.6–7.5 × 3.8–6.3 | This study |

|                         |  |  |                     |         |  |                     |                   |     |
|-------------------------|--|--|---------------------|---------|--|---------------------|-------------------|-----|
| <i>T. xixiacum</i>      | Pyramidal with opposing branches, less frequently solitary   | Ampulliform to lageniform, (3.2–)3.5–7.0(–9.3) × (2.3–)2.6–3.3(–3.6)   | (1.2–)1.5–2.5(–4)   | 1.6–2.2 | Subglobose to globose, (2.0–)2.3–2.7(–3.0) × (1.6–)2.0–2.6(–3.0) | 1.0–1.3(–1.7)       | Unobserved        | [1] |
| <i>T. simmonsii</i>     | Pyramidal, each branch terminating in a cruciate whorl of up 1–5 phialides                                     | Ampulliform to lageniform (4.2–)5.2–6.5 (–9.0) × (2.5–)3.0–3.7(–4.0)   | (1.2–)1.5–2.4(–3.3) | 1.7–2.2 | Subglobose to ovoid, (2.5–)2.7–3.2(–3.7) × (2.2–)2.5–3.0(–3.5)   | 1.0–1.1(–1.4)       | Sometimes present | [1] |
| <i>T. vermifimicola</i> | Pyramidal, the distance between branches relatively large, each branch terminating in a whorl of 2–3 phialides | Ampulliform to lageniform, (4.4–)5.0–10.5(–11.2) × (2.0–)2.5–3.0(–3.5) | (1.5–)1.8–2.8(–5.3) | 1.6–2.5 | Ovoid to subglobose, (2.0–)2.3–2.6(–3.0) × (1.5–)2.0–2.4(–2.8)   | (1.0–)1.1–1.4(–1.7) | Unobserved        | [2] |

**Supplementary Table S3.** Comparison of the morphological characteristics of *Trichoderma miyunense* and its relatives.

| Species             | Branching pattern  | Phialides (μm)  | Phialides L/W | Base width of Phialides (μm) | Conidia (μm)  | L/W of Conidia | Chlamydospore (μm) | Reference  |
|---------------------|--|---|---------------|------------------------------|---|----------------|--------------------|------------|
| <i>T. miyunense</i> | Pyramidal, multiple branches unpaired, often formed in whorls of 2–4 at the terminal of branches | Ampulliform to lageniform, (5.2–)5.6–9.7(–10.3) × 1.9–3.2(–3.7) | 1.9–4.4       | 1.0–2.1(–2.6)                | Ellipsoid, globose to subglobose, smooth, 2.2–3.4 × (1.8–)2–2.9 | 1–1.3(–1.4)    | Unobserved         | This study |

| Species                    | Metulae   | Metulae  | Metulae               | Metulae               | Metulae   | Metulae               | Metulae                                    | Metulae |
|----------------------------|---|--|-----------------------|-----------------------|---|-----------------------|--|---------|
| <i>T. ganodermatigerum</i> | Typically tree-like, straight, or slightly curved, often in whorls of 3–4 divergent phialides | Lageniform, spindly, (1.1–) 2.8–12.3 (–16) × (0.2–) 1.9–3.4 (–3.6) | (1.6–) 1.7–5.9 (–7.0) | (0.2–) 1.4–2.6 (–2.8) | Globose to subglobose, sometimes ellipsoid, (3.4–) 3.6–4.8 (–5.3) × (2.9–) 3.2–4.3 (–4.6) | 1.1–1.5               | Unobserved                                 | [3]     |
| <i>T. caeruloviride</i>    | Pyramidal, paired lateral branches, with 3–4 whorls of phialides                              | (5.2–) 5.3–12.2 (–13.2) × (1.7–) 2.0–2.8 (–3.48)                   | Not described         | Not described         | Ellipsoidal to ovoid, smooth, 2.2–3.0 (–3.2) × (1.9–) 2.3–3.1 (–3.4)                      | Not described         | 3.3–5.0 (–6.6) × 3.0–4.6 (–5.3)            | [4]     |
| <i>T. amazonicum</i>       | Pyramidal, short base of secondary branch, 3 or more phialides per metula                     | Ampulliform, 6.4–7.7 × 3.3–3.5                                     | (1.3–) 1.9–2.3 (–2.7) | (2.1–) 2.4–2.7 (–3.0) | Globose, scar generally visible, 3.2–3.4 × 3  | (1.0–) 1.1–1.2 (–1.3) | Chlamydospor e-like structures in clusters | [5]     |
| <i>T. pleuroti</i>         | Gliocladium-like  | Ampulliform, 4.2–7 × 2–4   | Not described         | Not described         | Ellipsoidal, 2.8–4.2 × 1.6–2.2  | Not described         | Yes  | [5]     |
| <i>T. pleurotica</i>       | Pyramidal, short base of secondary branch, 3 or more phialides per metula                     | Ampulliform, 5.5–11 × 3–4.2  | Not described         | Not described         | Subglobose, broadly ellipsoidal, scar sometimes obvious, 2.5–3.5 × 2.0–2.8                | 1.2                   | Yes  | [5]     |

|                           |  |   |                     |               |   |         |               |     |
|---------------------------|--|---|---------------------|---------------|---|---------|---------------|-----|
| <i>T. ceratophylletum</i> | Tree-like, often terminating in 3–5 phialides and paired branches, occasionally unilateral | Ampulliform to globose, (3.7–)4.1–8.4(–9.7) × 2.3–4.1               | (1.0–)1.2–2.8(–3.2) | Not described | Ovoid, sometimes ellipsoid, smooth, 2.5–3.9 × 1.9–2.9(–3.2) | 1.0–1.7 | Not described | [6] |
| <i>T. confertum</i>       | Tree-like, with a broad main axis, branches unpaired, rebranching up to 4 times            | Ampulliform, lageniform or subulate (6.9–)8.3–12.5(–20.8) × 2.5–4.2 | 2.0–6.3             | 1.4–2.9       | ellipsoid, globose to subglobose, smooth, 2.8–4.2 × 2.5–3.1 | 1.0–1.6 | Unobserved    | [7] |

**Supplementary Table S4.** Comparison of the morphological characteristics of *Trichoderma pholiotae* and its relatives.

| Species               | Branching pattern   | Phialides (μm)   | Phialides L/W | Base width of Phialides (μm) | Conidia (μm)   | L/W of Conidia | Chlamydospore (μm)  | Reference  |
|-----------------------|---|--|---------------|------------------------------|--|----------------|---|------------|
| <i>T. pholiotae</i>   | Pyramidal with opposing branches, with one terminal whorl of generality 3–4 phialides | Ampulliform or lageniform, (4.1–)4.9–10.9(–11.6) × 2.4–4.2(–5.0) | 1.4–3.4(–3.9) | (1.3–)1.4–3.1(–3.4)          | Elliptic to subspheroidal, less globose, smooth, 2.6–3.8(–4.2) × 2.4–3.3(–3.5) | 1–1.3          | Intercalary or terminal, ellipsoide, globose, 5.0–7.4(–8.3) × (3.9–)4.9–7.0 | This study |
| <i>T. guizhouense</i> | Verticillate and forming a more or less pyramidal structure                           | Ampulliform to lageniform, 4.5–10 × 2–3                          | Not described | Not described                | Globose, smooth, mostly 2–3  | Not described  | Unobserved  | [8]        |

|                           |  |   |                     |                     |   |                     |  |     |
|---------------------------|--|---|---------------------|---------------------|---|---------------------|--|-----|
| <i>T. simile</i>          | Tree-like, side branches arising from main axis asymmetrically, perpendicular to the axis              | Ampulliform, less lageniform with long, (3.8–)4.3–11.9(–14.3) × (2.3–)2.7–3.9 | 1.3–4.4(–5.2)       | 1.5–2.8(–3.6)       | Oval, elliptic to subspheroidal, less oblong, smooth, 2.6–3.2 × 2.2–2.8 | 1.0–1.2             | Elliptic or round, smooth, terminal and intercalary, 4.2–7.8 × 4.0–7.2 | [9] |
| <i>T. asiaticum</i>       | Comprise a distinct main axis with one terminal whorl of 4–5 phialides and mostly paired side branches | Ampulliform to lageniform, (3.0–)4.0–6.0(–7.0) × (1.0–)2.0–3.0(–4.0)          | (1.0–)1.3–3.0(–4.0) | Not described       | (2.3–)2.4–3.0(–3.1) × (2.0–)2.1–2.7(–2.8)                               | (1.0–)1.1–1.3(–1.4) | Unobserved   | [9] |
| <i>T. pseudoasiaticum</i> | Verticillium-like, typically with 1–3 branching levels   | Ampulliform, (5.2–)6.1–9.0(–9.7) × (2.1–)2.6–3.6(–4.0)                        | (1.1–)1.5–3.6(–5.2) | (1.0–)1.4–2.3(–2.6) | 2.4–3.2 × 2.4–3.0   | 1.0–1.1             | Globose, smooth, terminal, 4.7–7.7 × 4.0–7.6                           | [9] |

**Supplementary Table S5.** The growth rate of three new species in this study incubated at different temperatures and media.

|     | <i>T. auriculariae</i> |            |            | <i>T. miyunense</i> |            |            | <i>T. pholiotae</i> |            |            |
|-----|------------------------|------------|------------|---------------------|------------|------------|---------------------|------------|------------|
|     | 25 °C (mm)             | 30 °C (mm) | 35 °C (mm) | 25 °C (mm)          | 30 °C (mm) | 35 °C (mm) | 25 °C (mm)          | 30 °C (mm) | 35 °C (mm) |
| CMD | 65–66                  | 69–70      | 8–10       | 51–52               | 65–66      | No growth  | 71–72               | 73–74      | 13–18      |
| PDA | 47–49                  | 66–68      | 5–7        | 42–43               | 51–54      | No growth  | 67–68               | 70–72      | 8–10       |
| SNA | 47–49                  | 51–55      | 5–7        | 30–33               | 25–29      | No growth  | 49–50               | 54–55      | 8–10       |

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