

## NEW RECORD OF *Meliola irosinensis* IN *Schefflera macrocarpa* INCLUDING A KEY TO SPECIES OF *Meliola* ON ARALIACEAE

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A species of *Meliola* was collected parasitizing *Schefflera macrocarpa* (Araliaceae), in the Serra do Periperi, Vitória da Conquista, Bahia, Brazil which was morphologically identified as *Meliola irosinensis*. This species was compared with other 18 species of *Meliola* on the Araliaceae family. An identification key for the species of *Meliola* on Araliaceae was developed. *S. macrocarpa* is a new host to *M. irosinensis* and its occurrence in Brazil expands its geographical distribution from Asia to America.

**Key words:** Araliaceae, black mildews, key to species, Meliolales, morphology.

**Novo registro de *Meliola irosinensis* em *Schefflera macrocarpa* incluindo uma chave para espécies de *Meliola* em Araliaceae.** Uma espécie de *Meliola* foi coletada parasitando *Schefflera macrocarpa* (Araliaceae), na Serra do Periperi, Vitória da Conquista, Bahia, Brasil que foi morfológicamente identificada como *Meliola irosinensis*. Esta espécie foi comparada com outras 18 espécies de *Meliola* da família Araliaceae. Foi desenvolvida uma chave de identificação para as espécies de *Meliola* em Araliaceae. *S. macrocarpa* é um novo hospedeiro para *M. irosinensis* e sua ocorrência no Brasil expande sua distribuição geográfica da Ásia para a América.

**Palavras-chave:** Araliaceae, míldios negros, chave para as espécies, Meliolales, morfologia.

## Introduction

The Meliiales is a group of epifoliar fungi, obligate parasites or obligate symbionts (Reynolds & Gilbert, 2005; Gilbert, Reynolds & Bethancourt, 2007), that forms dark colonies known as black mildews. The genus *Meliola* is the most important of this order, occurring on leaves, petioles, twigs and fruits. They produce haustoria that penetrate leaf surface to gain nutrients from host plants, which results in a reduction of chlorophyll, starches, sugars, proteins and amino acids, however, without causing pathogenic damage (Zeng et al., 2020). *Meliola irosinensis* in *Schefflera macrocarpa*, species described in this work, is an example of this type of relationship.

The genus *Meliola* emerged around 35 million years ago (Hongsanan et al., 2016). According to Zeng et al. (2017), species of Meliolaceae are believed to be host-specific, as they parasitize only indigenous plants of any particular area and are limited to a narrow range of host plants that rarely extends to more than one botanical family. Host switching between closely related plants in the same genus has not been observed, whereas shifting between different plant genera in the same family or more distant plants has occurred. This indicates that phylogenetically related Meliolaceae species do not appear to infect similar plants and are found on their original host or jump to a more distant host (Gilbert, Reynolds & Bethancourt, 2007). The genus *Meliola* has more than 3000 described species (Index Fungorum, 2021). In the Araliaceae family, Soares (2012) cites 17 species of *Meliola*. Pinho et al. (2012a) expands the species list to 19. Hansford identified *Meliola schefflerae* on hosts *Schefflera aromatica*, *Schefflera polybotrya*, in Java and *Schefflera* sp. in the Philippines.

In this work, a species of *Meliola* was identified on *S. macrocarpa*. The objectives of this study were:

- i) report *Meliola irosinensis* on *S. macrocarpa*;
- ii) update the list of *Meliola* species on Araliaceae adding *Meliola fatsiae* and *Meliola abdukalami* and their respective Beeli formula; and iii) produce an identification key for the species of *Meliola* on Araliaceae.

## Materials and Methods

The species of *Meliola* studied in the present work were collected from leaves of *Schefflera macrocarpa*

(Araliaceae), with signs of black mildews. The host specimen was collected in Serra do Periperi (S 14° 49' 52,55" - W 40° 50' 1,86", Alt. 1062 m), Vitória da Conquista, Bahia, Brazil, in January 2020. The collected samples were photographed and submitted for analysis at the Phytopathology Laboratory of the State University of Southwest Bahia.

The fungal structures were removed from the leaves with needles and mounted on slides with lactophenol (Hosagoudar & Kapoor, 1985). Thirty measurements were taken of each of the following fungal structures: 1. Diameter of perithecia; 2. Length of ascospores; 3. Width of ascospores; 4. Length of mycelial setae. For the species of *Meliola* identified in *Schefflera macrocarpa*, *Meliola fatsiae* and *Meliola abdukalami* the Beeli formula was calculated according to Hansford (1961). An Ipad® Pro 9.7" with a 12 megapixel digital camera was used to obtain the photographs.

A Table 1 with the 19 species of *Meliola* reported in Araliaceae was constructed showing the species of *Meliola*, the Beeli formula, pertinent references and hosts. In Beeli's formula of each species, numbers in bold and underlined indicate in how many characters each species differs from *Meliola irosinensis* the target species of this paper. To identify this species, it was necessary to compare the descriptions of all *Meliola* species described on Araliaceae which made possible to elaborate a key to the species of *Meliola* on Araliaceae (Table 2).

## Results

A species of *Meliola* was identified occurring on the plant host *Schefflera macrocarpa* of the Araliaceae family.

### Description of the species

#### *Meliola irosinensis* Syd. (Figure 1)

**Host plant:** *Schefflera macrocarpa* (Cham. & Schltdl) Frodin (Araliaceae) CEPEC-FUNGI 2665, 22/112015. Serra do Periperi (S 14° 49' 52,55" - W 40° 50' 1,86", Alt. 1062 m), Vitória da Conquista, Bahia, Brazil.

**Beeli formula:** 3113.4221

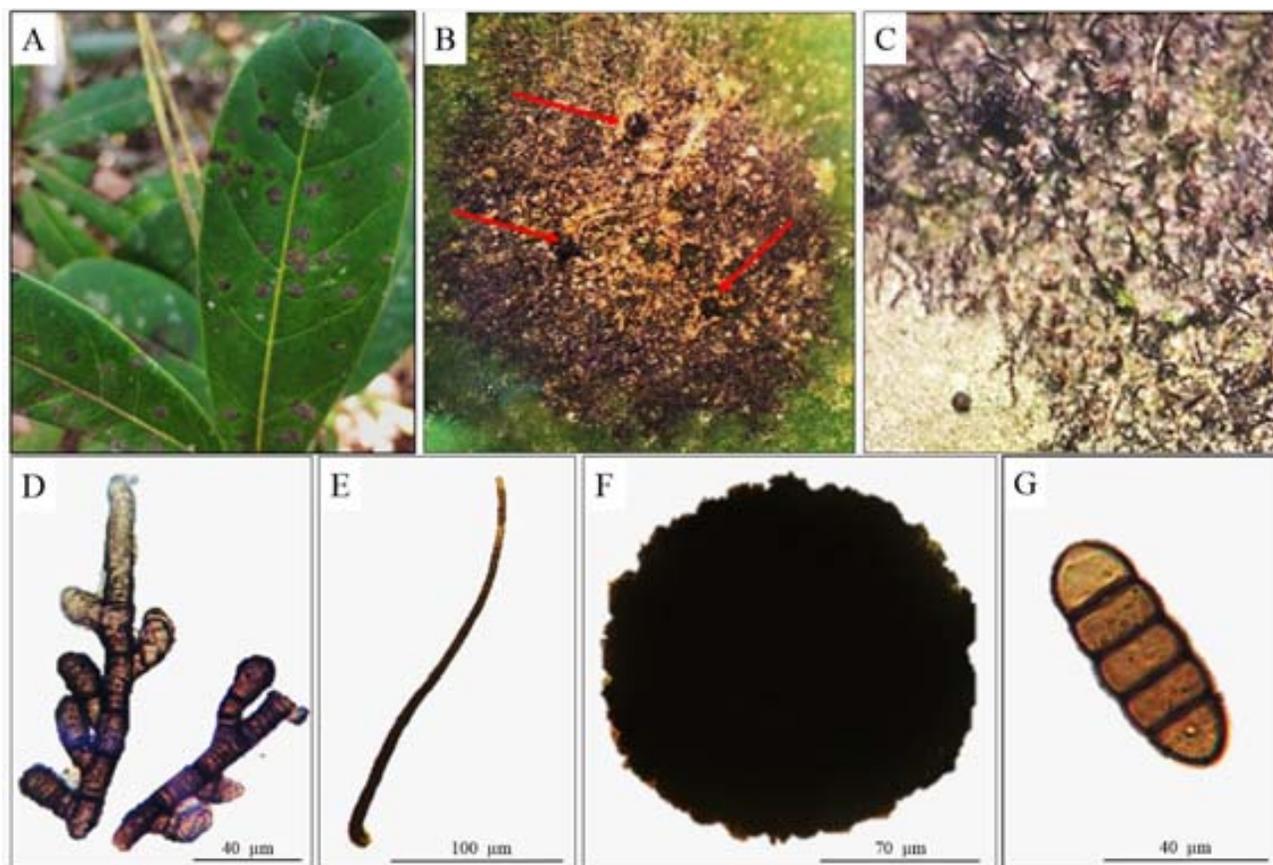


Figure 1 - A. Epiphyllous colonies. B. Perithecia in colony C. Colony detail. D. Capitulate hyphopodia. E. Mycelial seta. F. Perithecia. G. Ascospore.

Colonies superficial, hypophyllous, dense, 4 mm diam, dark brown to dark, ascospore 4 septate (Figure 1G), length, variation observed for normal spore 41-50 µm, ascospore width, variation observed for normal spore 11 - 20 µm; perithecia without setae or appendages, variation diameter observed 101 - 200 µm; mycelial setae simple (Figure 1E), entire, not uncinete or coiled, length up to 300 µm; capitulate hyphopodia mixed opposite and alternate, variation observed 20-30 x 10-15 µm (Figure 1D).

Table 1 shows an updated of *Meliola* species, with the respective Beeli formula, including: *Meliola fatsiae* and *M. abulkalamii*.

### Discussion

In the southwest region of Bahia-Brazil, where this work was carried out, species of this genus do not develop during the dry months of August,

September and October. This observation agrees with Zeng et al. (2017) who cites that they are absent in arid regions, which indicates that a minimum water-requirement or humidity level is needed for their development.

The species *Meliola irosinensis* identified in this work on *Schefflera macrocarpa* had been reported for the first time in the Philippines in 1915, on *Boerlagiodendron mindanaense* Merr., Araliaceae (Bánki et al., 2021), in addition to *Meliola boerlagiodendri* H.S. Yates. The species *M. schefflerae* Hansf., occurs in the Philippines and Java. *Meliola pectinata* Hohn., was found in *Schefflera polybotrya* also in Java; furthermore, other species of *Meliola* were found in *Schefflerae ceriferae* in New Caledonia as *M. montis-fontium* B. Huguenin, and in other hosts as *Meliola heteroseta* Hoehn, in *Schefflera* sp. and *Schefflera polybotrya* found in Java, and on *Schefflera octophylla* in China (Hansford, 1961). With

Table 1- Different species of *Meliola* reported in Araliaceae

Species of <i>Meliola</i>	Beeli Formula	Searching reference	Original reference	Host
<i>Meliola irosinensis</i> Syd.	3113.4221	Hansford, 1961.	Sydow, 1925.	<i>Boerlagodendrum</i> (Philippines).
<i>Meliola didymopanax</i> P. Henn.	3123.4221	Hansford, 1961.	Hennings, 1895.	<i>Didymopanax</i> (Brazil).
<i>Meliola boerlagiodendri</i> H.S. Yates.	3143.4221	Hansford, 1961.	Yates, 1918.	<i>Boerlagiodendron</i> (Philippines).
<i>Meliola schefflerae</i> Hansf.	3113.5221	Hansford, 1961.	Hansford, 1954.	<i>Schefflera</i> sp., (Philippines); <i>S. polybotrya</i> (Java); <i>S. aromatica</i> (Java); <i>Aralia</i> sp., (New Guinea).
<i>Meliola didymopanax</i> var. <i>domingensis</i> Hansf.	31 $\frac{1}{2}$ 3. 3221	Hansford, 1961.	Hansford, 1955.	<i>Didymopanax marotoni</i> (San Domingos).
<i>Meliola didymopanax</i> var. <i>polysciatis</i> Hansf.	3121.4221	Hansford, 1961.	Hansford, 1955.	<i>Polyscias fulva</i> (Uganda).
<i>Meliola didymopanax</i> var. <i>stevensii</i> Hansf.	3113.4234	Hansford, 1961.	Beeli, 1920.	<i>Dendropanax arboreum</i> ; <i>D. laurifolia</i> ; on Araliaceae indet.
<i>Meliola payakii</i> Hosag.	3113.4232	Pinho et al., 2012a.	Hosagoudar, 1996.	<i>Hedera helix</i> (Simla, Índia).
<i>Meliola brassaiopsidis</i> Hosag.	3123.4222	-	Hosagoudar, 1996.	<i>Brassaiopsis</i> sp. (Himalan).
<i>Meliola dichotoma</i> Berk. & M.A. Curtis.	3143.4231	Hansford, 1961.	Berkeley & Curtis 1860.	<i>Hedera</i> sp.; <i>Hedera formosana</i> (Japan).
<i>Meliola dichotoma</i> var. <i>kusanoi</i> P. Henn.	31 $\frac{1}{4}$ 3.4231	Hansford, 1961.	Hennings, 1901.	<i>Hedera helix</i> (Japan).
<i>Meliola araliicola</i> W. Yamam.	3111.4233	Hansford, 1961.	Yamamoto, 1941.	<i>Aralia decaisneana</i> (Formosa).
<i>Meliola acanthopanax</i> W. Yamam.	3113.5233	Hansford, 1961.	Yamamoto, 1941.	<i>Acanthopanax trifoliatum</i> (Formosa).
<i>Meliola heteroseta</i> Höhn.	3143.5331	Hansford, 1961.	Höhnel, 1909.	<i>Schefflera</i> sp; (Java) <i>S. polybotrya</i> (Java); <i>S. octophylla</i> (China); <i>Cussonia spicata</i> (South Africa).
<i>Meliola pectinata</i> Hohn.	3112.6331	Hansford, 1961.	Höhnel, 1919.	<i>Schefflera polybotrya</i> (Java)
<i>Meliola fatsiae</i> Katum. & Y. Harada.	3112.5332	-	Katumoto & Harada, 1979.	<i>Fatsia oligocarpella</i> (Japan)
<i>Meliola tieghemopanax</i> B. Huguenin.	3121.5331	-	Huguenin, 1969.	<i>Tieghemopanax</i> sp. (Nova Caledonia)
<i>Meliola abdulkalami</i> Hosag & Riju.	3131.3132	-	Hosagoudar et al., 2013.	<i>Aralia</i> sp. (Kerala-Índia)
<i>Meliola montis-fontium</i> B. Huguenin.	3141.6342	Mibey & Cannon, 1999.	Huguenin, 1969.	<i>Schefflerae ceriferae</i> (Nova Caledonia)

*M. irosinensis* on *S. macrocarpa*, the species of *Meliola* on this host genus is increased to five.

According to Zeng et al. (2017), Meliolales species are host-specific and numerous new species were introduced based on the association of specific hosts.

Hansford (1961) cites that the Meliolineae parasitize only the indigenous plants of any particular area, though in some instances they may spread from these to introduced or cultivated plants closely allied to their native hosts. According to Hongsanan et al. (2015), most of

Table 2. Key to *Meliola* species on Araliaceae

MYCELIAL SETAE SIMPLE	
1. Hyphopodia alternate or unilateral.....	<i>M. araliicola</i>
1' Hyphopodia opposite or opposite and alternate.....	2
2. Hyphopodia regularly opposite.....	3
2' Hyphopodia opposite and alternate.....	4
3. Ascospores larger than 60 µm long.....	<i>M. pectinata</i>
3' Ascospores 51-60 µm long.....	<i>M. fatsiae</i>
4. Mycelial setae above 1000 µm long.....	<i>M. didymopanax</i> var. <i>stevensii</i>
4' Mycelial setae up to 1000 µm long.....	5
5. Ascospores 41-50 µm long.....	6
5' Ascospores 51-60 µm long.....	7
6. Perithecia 101-200 µm diam.....	<i>M. irosinensis</i>
6' Perithecia 201-300 µm diam.....	<i>M. payakii</i>
7. Perithecia 101-200 µm diam.....	<i>M. schefflerae</i>
7' Perithecia 201-300 µm diam.....	<i>M. acanthopanax</i>
MYCELIAL SETAE UNCINATE	
1. Hyphopodia alternate or unilateral.....	2
1' Hyphopodia opposite and alternate.....	3
2. Perithecia 101-200 µm diam; ascospores 41-50 µm long.....	<i>M. didymopanax</i> var. <i>polyciatis</i>
2' Perithecia 201-300 µm diam; ascospores 51-60 µm long.....	<i>M. thieghemopanax</i>
3. Ascospores 31-40 µm long.....	<i>M. didymopanax</i> var. <i>domingensis</i>
3' Ascospores 41-50 µm long.....	4
4. Mycelial setae up to 300 µm long.....	<i>M. didymopanax</i>
4' Mycelial setae 300-500 µm long.....	<i>M. brassaiopsidis</i>
MYCELIAL SETAE BRANCHED OR FURCATE	
1. Hyphopodia alternate and unilateral.....	2
1' Hyphopodia opposite and alternate.....	3
2. Ascospores 31-40 µm long.....	<i>M. abdukalamii</i>
2' Ascospores above 40 µm long.....	4
3. Perithecia 101-200 µm diam; mycelial setae branched.....	<i>M. boerlagiendri</i>
3' Perithecia 101-200 µm diam; mycelial setae also simple.....	<i>M. dichotoma</i> var. <i>kusanoi</i>
4. Ascospores above 60 µm long.....	<i>M. montisfontium</i>
4' Ascospores shorter than 60 µm long.....	5
5. Ascospores 41-50 µm long.....	<i>M. dichotoma</i>
5' Ascospores 51-60 µm long.....	<i>M. heteroseta</i>

Meliolales species have been justified based on host association and it is essential to establish the host genus or family before describing a new species. Hongsanan does not agree, however, with the introduction of new species of *Meliola* based only on host specificity. For this author, the host specificity

would have to be confirmed through molecular techniques.

Probably because the fungus is biotrophic and cannot be cultivated in culture, there is no sequence of *Meliola* species on in the Araliaceae family in the GenBank. There is a need to propose improved protocols for DNA extraction from *Meliola* species (Pinho et al., 2012b) so that doubts about host specificity of *Meliola* species can be resolved.

According to Hongsanan et al. (2015), *Meliola* specimens collected from *Dimocarpus longan* (Sapindales) and from *Acacia auriculiformis* (Fabales) were identified as the same species according to molecular analyses. This has important implications as the several hundred *Meliola* species are recognized based on morphology and host associations. Few records of a same species occurring on two unrelated hosts sheds doubt about *Meliola* species being host specific. In Brazil, *Meliola mangiferae* Earle and *Meliola decidua* Speg., are found consistently on *Mangifera indica* L., and *Meliola psidii* Fr., in the same way, occurs on *Psidium guajavae* Raddi (Mendes & Urben, 2021). This clearly points to a host preference of these species.

This record of *Meliola irosinensis* on *Schefflera macrocarpa*, expands to five the number of species of *Meliola* hosted on the genus *Schefflera*.

## Conclusion

As more collections of *Meliola* species are done throughout the world, new hosts and geographic records are discovered, as is the case of *Meliola irosinensis* presently reported on a new host (*Schefflera macrocarpa*) and in a new geographic locality (America). Improved molecular studies and cross inoculations are required in order to shed more light into *Meliola* ways of parasitism.

## Literature Cited

- BÁNKI, O. et al. 2021. Catalogue of Life Checklist (Version 2021-08-25). <https://doi.org/10.48580/d4sg>.
- BEELI, M. 1920. Note sur le genre *Meliola* Fr. Bulletin du Jardin Botanique Bruxelles 7:89-160.

- BERKELEY, M. J.; CURTIS, M. A. 1860. Characters of new fungi, collected in the North Pacific exploring expedition by Charles Wright. *Proceedings of the American Academy of Arts and Sciences* 4:111-130.
- GILBERT, G. S.; REYNOLDS, D. R.; BETHANCOURT, A. 2007. The patchiness of epifoliar fungi in tropical forests: host range, host abundance, and environment. *Ecology*, 88:575-581.
- HANSFORD, C. G. 1961. The Meliolaceae - A monograph. *Beihefte zur Sydowia* 2:1-806.
- HANSFORD, C. G. 1954. Some Microthyriales and other fungi from Indonesia. *Reinwardtia* 3:113-144.
- HANSFORD, C. G. 1955. *Sydowia* 9:15.
- HENNINGS, P. 1901. *Fungi japonici*. *Engler's bot Jahrbuch* 8:272.
- HENNINGS, P. 1895. *Hedwigia* 34:106.
- HÖHNEL, F. von. 1919. Fragmente zur Mykologie. XXII. Mitteilung. Nr. 1154-1188. In: *Sitzungsberichten der Kaiserlich Akademie der Wissenschaften I Wien. Mathematisch-naturwissenschaft Klasse* 198:535-625.
- HÖHNEL, F. von. 1909. Fragmente zur Mykologie. IX. Mitteilung. Nr. 407-467. In: *Sitzungsberichten der Kaiserlich Akademie der Wissenschaften I Wien. Mathematisch-naturwissenschaft Klasse, Abt 1*. 188:1461-1552.
- HONGSANAN, S. et al. 2016. The evolution of fungal epiphytes. *Mycosphere* 7:1690-1712.
- HONGSANAN, S. et al. 2015. Meliolales. *Fungal Diversity* 74(1):91-141.
- HOSAGOUDAR, V. B.; KAPOOR, J. N. 1985. New technique of mounting Meliolaceous fungi. *Indian Phytopathology* 38:548-549.
- HOSAGOUDAR, V. B. et al. 2013. Meliolales of India. *Journal of Threatened Taxa* 5(3):3993-4068.
- HOSAGOUDAR, V. B. 1996. Meliolales of India. *Botanical Survey of India, Calcutta*. 363p.
- HUGUENIN, B. 1969. *Meliola dognyensis*. *Revue Mycologique* 34:52.
- INDEX FUNGORUM. 2021. *Meliola* species. Disponível em: <http://www.indexfungorum.org/names/Names.asp>. Acesso em 25 de outubro de 2021.
- KATUMOTO, K.; HARADA, Y. 1979. Plant parasitic fungi from the Bonin Islands: II Ascomycotina and Deuteromicotina. *Transactions of the Mycological Society of Japan* 20 940:411-428.
- MENDES, M. A. S.; URBEN, A. F. 2021. Fungos relatados em plantas no Brasil, Laboratório de Quarentena Vegetal. Brasília, DF, Embrapa Recursos Genéticos e Biotecnologia. Disponível em: <http://pragawall.cenargen.embrapa.br/aiqweb/michtml/fgbanco01.asp>. Acesso em: 10/11/2021
- MIBEY, R. K.; CANNON, P. F. 1999. Biotrophic fungi from Kenya. Ten new species and some new records of Meliolaceae. *Cryptogamie Mycologica* 20:249-282.
- PINHO, D. B. et al. 2012a. Species on hosts in the families Asteraceae, Burseraceae, Euphorbiaceae, Fabaceae and Sapindaceae. *Mycologia* 104:121-137.
- PINHO, D. B. et al. 2012b. An efficient protocol for DNA extraction from Meliolales and the description of *Meliola centellae* sp. nov. *Mycotaxon* 122:333-345.
- REYNOLDS, D. R.; GILBERT, G. S. 2005. Epifoliar fungi from Queensland, Australia. *Australian Systematic Botany* 18:265-289.
- SOARES, W. R. O. 2012. Meliolaceae em plantas do Cerrado. *Dissertação de Mestrado*. Brasília, DF, UNB. 91p.
- SYDOW, H. 1925. *Leaflets of Philippine Botany* 9:3118-3119.
- YAMAMOTO, W. 1941. In: *Transactions, Natural History Society of Formosa* 31:224.
- YATES, H. S. 1918. *Meliola boerlagiodendri*. *Philippine Journal of Science* 13:365-366.
- ZENG, X. Y. et al. 2020. Unravelling evolutionary relationships between epifoliar Meliolaceae and angiosperms. *Journal of Systematics and Evolution*. <https://doi.org/10.1111/jse.12643>.
- ZENG, X. Y. et al. 2017. A checklist for identifying Meliolales species. *Mycosphere* 8(1):218-359. ●