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Four new species of *Coenogonium* (Ascomycota: Ostropales) from vulnerable forest ecosystems in Puerto Rico

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Abstract. Four new species of *Coenogonium* are described from the Caribbean island of Puerto Rico—*C. aurantiacum* Mercado-Díaz & Lücking, *C. borinquense* Mercado-Díaz & Lücking, *C. dimorphicum* Mercado-Díaz & Lücking and *C. portoricense* Mercado-Díaz & Lücking. All were discovered in small and highly fragmented forest remnants of relatively rare Puerto Rican forest ecosystems, *Pterocarpus* wetlands and non-calcareous dry forests. The discoveries are discussed relative to the conservation status of these threatened ecosystems, the need to catalogue biodiversity before it vanishes, and the notion that endemism in lichenized fungi in island biotas is potentially much higher than hitherto assumed. A previous world-wide key to *Coenogonium* is updated to accommodate the new taxa.

Keywords. Biodiversity hotspots, endemism, island biota.

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The Caribbean islands have been identified as biodiversity hotspots, and along with 24 other regions, represent the biologically richest and at the same time most endangered terrestrial ecoregions in the world (Myers 2000). Puerto Rico is the smallest island of the Greater Antilles in the Caribbean, and compared to larger neighboring islands like Cuba and Hispaniola it exhibits a general trend towards lower species diversity for many groups of organisms (Losos & Schluter 2000; Rabosky & Glor 2010). However, compared to other islands of similar size throughout the world, Puerto Rico's diversity for many groups is notable. For example, the territory has about 2,255 species of native vascular plants, whereas Fiji has 1,600 and the Hawaiian islands have 1,400 (Santiago-Valentín 2008; Imada 2012).

Puerto Rico's high biodiversity is surprising, considering that 95% of the island was deforested by the first half of the 20th century (Santiago-Valentín 2008). However, a shift from agriculture to manufacturing and human migration from rural to urban areas led to an increase in forest cover, from less than 10% in the late 1940's to more than 40% in the early 21st century (Grau et al. 2003). By 2003, the main island of Puerto Rico had 57% forest cover (Brandeis et al. 2007).

Over the last decades, Puerto Rico has undergone a rapid urban expansion at the expense of lowland areas such as pastures in abandoned agricultural lands (López et al. 2001). Forest recovery has continued, but has shown signs of slowing down (Kennaway & Helmer 2007). At first glance, these land cover changes may be attributed to the consequences of satisfying the demands of Puerto Rico's large population density. About 3.7 million persons live on the 9,000 km^2 large island, which makes it the most densely populated territory in all of the Americas [http://data.worldbank.org/indicator/EN.POP.DNST]. The lack of coherent urban planning has been shown to be the main reason for the uncontrolled expansion of urban land cover on the island (Martinuzzi et al. 2007).

Although representing an important component of forest biodiversity (McCune 2000), lichens have not been thoroughly studied in Puerto Rico (Mercado-Díaz & Santiago-Valentín, 2010). In general, these organisms remain poorly characterized in tropical regions, where possibly half of the global lichen diversity is expected to occur (Lücking et al. 2009). This situation poses a challenge for the conservation of

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biodiversity, especially because there may be unknown species on the brink of extinction to be found in vulnerable areas such as forest remnants or forest ecosystems with limited coverage on the island. In addition, other influencing factors such as climate change and the lack of effective implementation of natural resource conservation strategies may further reduce the chances of successfully implementing preventive measures before extinction occurs. Altogether, these issues emphasize the need to characterize the diversity of poorly known organisms such as lichens to guarantee their future survival. For Puerto Rico, the preliminary checklist of lichens and lichenicolous fungi represents a first step in this direction (Mercado-Díaz 2009). This work lists a total of 1,181 lichen species for the island (Mercado-Díaz 2009; Mercado-Díaz and Santiago-Valentín, 2010); however, recent estimates for the island suggest that lichens may reach 1,600 species (Lücking et al. 2009).

Coenogoniaceae is a monogeneric family with the single genus *Coenogonium*, characterized by a crustose or filamentous thallus with *Trentepohlia* photobiont and biatorine, mostly yellow to orange apothecia. The thin-walled, unitunicate asci, unbranched paraphyses, and small, simple to 1-septate ascospores make this genus easily recognizable (Rivas Plata et al. 2006). Species mostly grow in the shaded understory of tropical rain forests on tree trunks, branches, lianas, and leaves (Lücking 2008; Rivas Plata et al. 2008). In spite of the relatively uniform apothecial anatomy, the genus contains a large number of species, distinguished mostly by morphological features and ascospore size and shape, and it has been estimated that many more species await discovery (Rivas Plata et al. 2006).

In this paper, we describe four new species of *Coenogonium* from *Pterocarpus* wetlands and non-calcareous dry forests in Puerto Rico, which represent small isolated forest fragments in large urban areas. This discovery is particularly relevant in view of the partially unique lichen biota of the island and the current conservation status of these lowland ecosystems. Since the genus *Coenogonium* is rather well-known in continental areas bordering the Caribbean (e.g., Florida, Costa Rica; Lücking et al. 2011; Rivas Plata et al. 2006), we suspect that these newly discovered species represent potentially endemic taxa.

Materials and Methods

Specimens were collected in established research plots which are part of an ongoing study describing different ecological parameters in eight forest ecosystems present in the northeastern portion of the island (González et al. 2007; Gould et al. 2006). The new species described here were found exclusively in two of these ecosystems (**Fig. 1**)—*Pterocarpus* wetlands and non-calcareous dry forests. *Pterocarpus* wetlands commonly occur along the coast, although a few are present along streams in northeastern Puerto Rico (Alvarez-López 1990). These forests are almost entirely a monoculture of the swamp bloodwood tree, locally known as ''Palo de Pollo'' (*Pterocarpus officinalis*) and typically occur on seasonally flooded, non-calcareous alluvial substrates (Gould et al. 2006). *Pterocarpus* forests occupy approximately 0.03% of Puerto Rico's surface area (Gould et al. 2007), making them one of the rarest forest ecosystems of the island (Miller & Lugo 2009). Similar to *Pterocarpus* forests, non-calcareous dry forests have a discontinuous distribution throughout Puerto Rico (Gould et al. 2007). The best representations of these forests are found to the southwest in Sierra Bermeja Mountains, and to the east in Culebra, Vieques and few scattered patches between Fajardo and Naguabo (Gould et al. 2007; Lugo 2005). Common tree species include *Bucida buceras* (Úcar), *Guapira fragrans* (Corcho) and *Bursera simaruba* (Almácigo) (Gould et al. 2006). Non-calcareous dry forests occupy about 1.2% of Puerto Rico's surface area (Gould et al. 2007).

Thallus morphology was examined using a Leica MS5 dissecting microscope. Sections of thalli and ascomata were cut by hand with a razor blade and examined with squash preparations in water, KOH and Lugol's solution, using a Zeiss Axioskop 2 compound microscope. All measurements are given in water. TLC was done using standard techniques with solvent C (Orange et al. 2010).

Taxonomy

Coenogonium aurantiacum Mercado-Díaz & Lücking, *sp. nov.* **Fig. 2A–B**

Mycobank MB 805799

Differing from Coenogonium luteocitrinum in the orange instead of yellow apothecia, the prominent apothecial margin, and the shorter ascospores.

Type: Puerto Rico. Municipality of Ceiba, Barrio Daguao, Former U.S. Naval Station Roosevelt Roads, road PR-979, south of Río Daguao; 18°13′15″ N, 65°40′15″ W, 14 m; on trunk of tree; *Mercado-Díaz 860* (holotype: F; isotype: UPR).

Description. Thallus corticolous, crustose, continuous, thin, smooth, green to olive-green, 5–10 cm diam., with cartilaginous corticiform layer; prothallus absent. Photobiont *Trentepohlia*, cells angular-rounded, in irregular plates or groups or short threads, 5–10 μm diam. Apothecia sessile, rounded to slightly

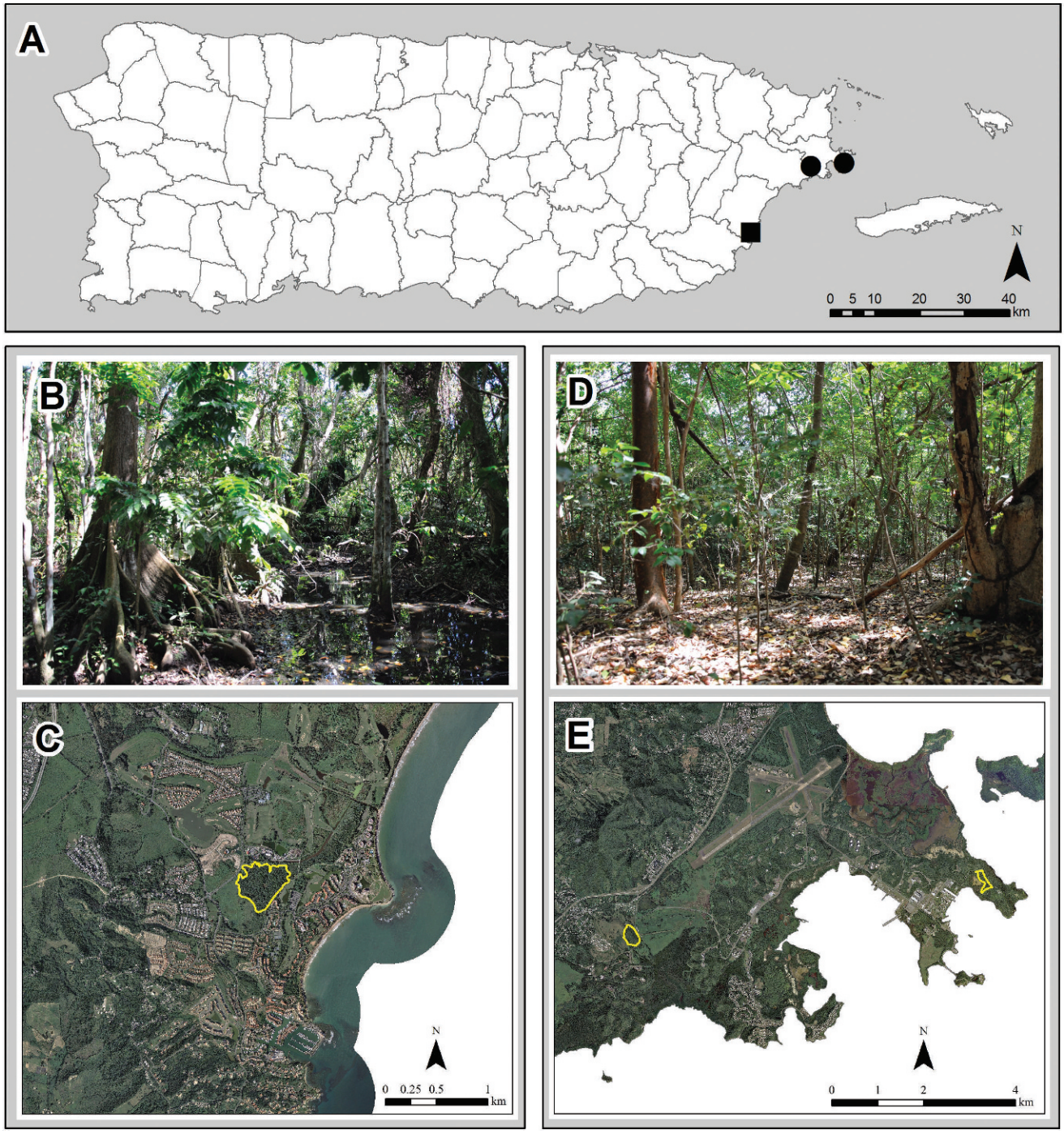

Figure 1. A. Map of Puerto Rico municipalities showing collection sites for *Coenogonium aurantiacum* and *C. borinquense* (circles), and *C. dimorphicum* and *C. portoricense* (square). **B.** View inside of a *Pterocarpus* forest. Humacao, PR. **C.** Map showing the *Pterocarpus* forest patch where *C. dimorphicum* and *C. portoricense* were collected. **D.** View inside a non-calcareous dry forest. Ceiba, PR. **E.** Map showing the dry forest patches where *C. aurantiacum* and *C. borinquense* were collected.

irregular in outline, 0.4–0.7 mm diam. and 200–300 µm high; disc plane, orange; margin distinct, slightly prominent, rough, (pale) orange. Excipulum paraplectenchymatous with peripherally radiating cell rows, 80–150 µm broad, colorless except upper, bright yellow-orange edge, I–; cells isodiametric and thick-walled in inner parts, 3–6 × 3–5 µm, in peripheral parts radially elongated and thin-walled, 5–10 × 4–6 µm. Hypothecium 25–50 µm, pale yellowish. Hymenium 70–80 µm, colorless, I+ blue then sordid blue-green. Asci 55–65 × 5–6 µm. Ascospores uniseriate, ellipsoid, 1-septate, 5–7 × 2–2.5 µm, 2.5–3 times as long as broad. Pycnidia not observed. Chemistry: no substances detected by TLC.

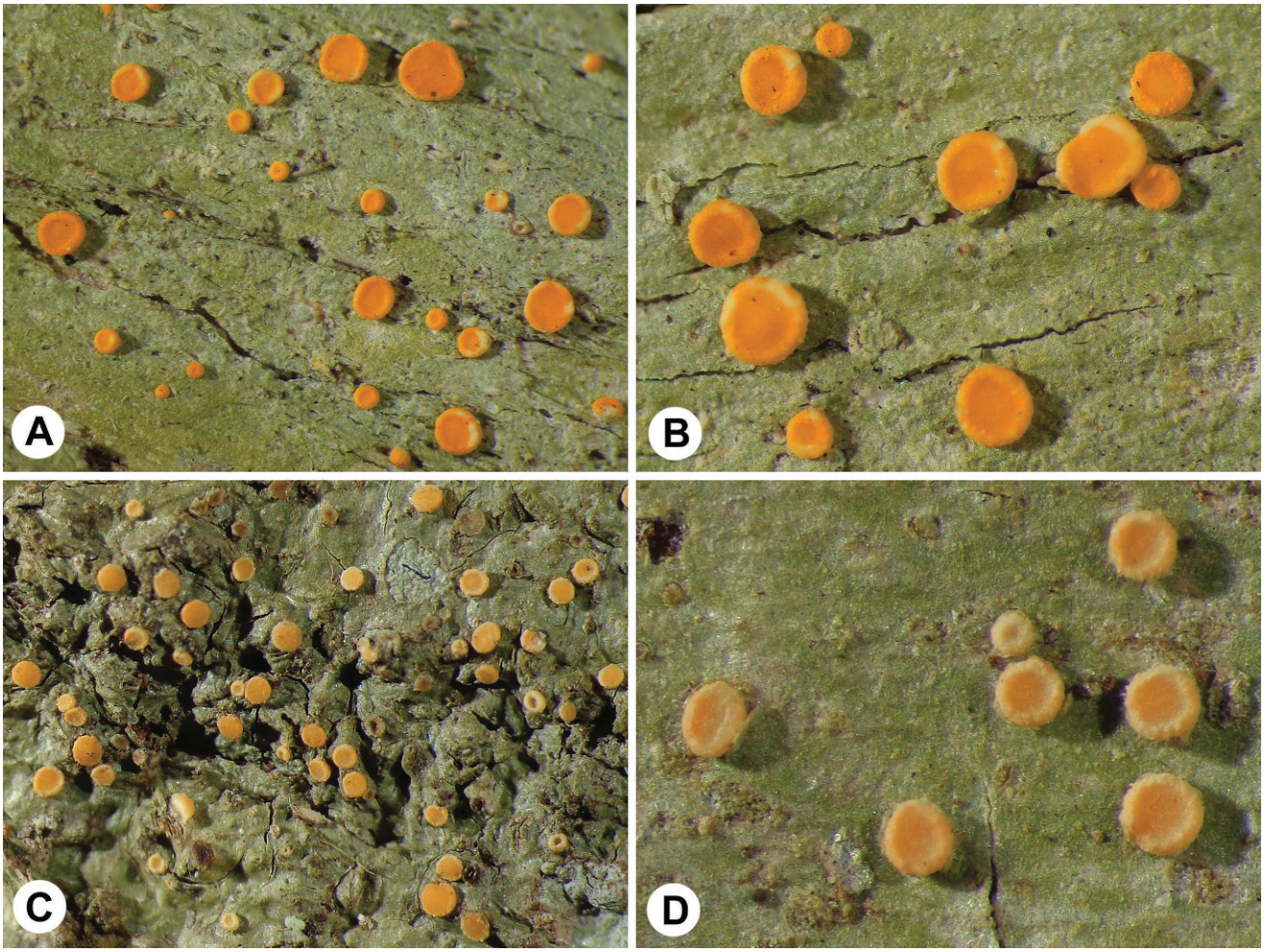

Figure 2. A–B. *Coenogonium aurantiacum* (holotype). **A.** Thallus with apothecia; **B.** Detail of apothecia. **C–D.** *Coenogonium borinquense* (holotype). **C.** Thallus with apothecia; **D.** Detail of apothecia.

Distribution and ecology. Known from the well-developed type collection from an isolated non-calcareous dry forest patch within the former U.S. Naval Station Roosevelt Roads in the municipality of Ceiba, at 14 m altitude. It was found growing on living tree trunks under partly shaded conditions.

Discussion. This new species is characterized by bright orange apothecia of medium size, with prominent, rough margins, and very short ascospores. It is most similar to *Coenogonium luteocitrinum* Rivas Plata, Lücking & Umaña (Rivas Plata et al. 2006), but differs in the distinctly orange tinge of the apothecia, the prominent, rough apothecial margin, the slightly smaller but higher apothecia, and the very short ascospores. *Coenogonium siquirrense* (Lücking) Lücking shares the orange apothecia with *C. aurantiacum*, but it has a darker orange marginal zone and orange, either smooth or denticulate margin of the apothecia, longer ascospores and a shiny thallus with glossy, white prothallus (Rivas Plata et al. 2006).

Coenogonium borinquense Mercado-Díaz & Lücking, *sp. nov.* **Fig. 2C–D**

Mycobank MB 805800

Differing from Coenogonium saepincola in the greyish green thallus and the larger ascospores.

Type: Puerto Rico. Municipality of Ceiba, Barrio Machos, Former U.S. Naval Station Roosevelt Roads, Forrestal Drive, Punta Puerca; 18°13′53″ N, 65°35′54″ W, 10 m; on trunk of tree; *Mercado-Díaz 861* (holotype: F; isotype: UPR); ibid., *Mercado-Díaz 862* (paratype: UPR).

Description. Thallus corticolous, crustose, continuous, thin, smooth, greyish green, glossy, 3–7 cm diam., with cartilaginous corticiform layer; prothallus white-grey, glossy. Photobiont *Trentepohlia*, cells angular-rounded, in irregular plates or groups or short threads, 5–10 µm diam. Apothecia sessile, rounded, 0.2–0.4 (–0.5) mm diam. and 180–230 µm high; disc plane, pale orange-yellow; margin distinct, not prominent except in

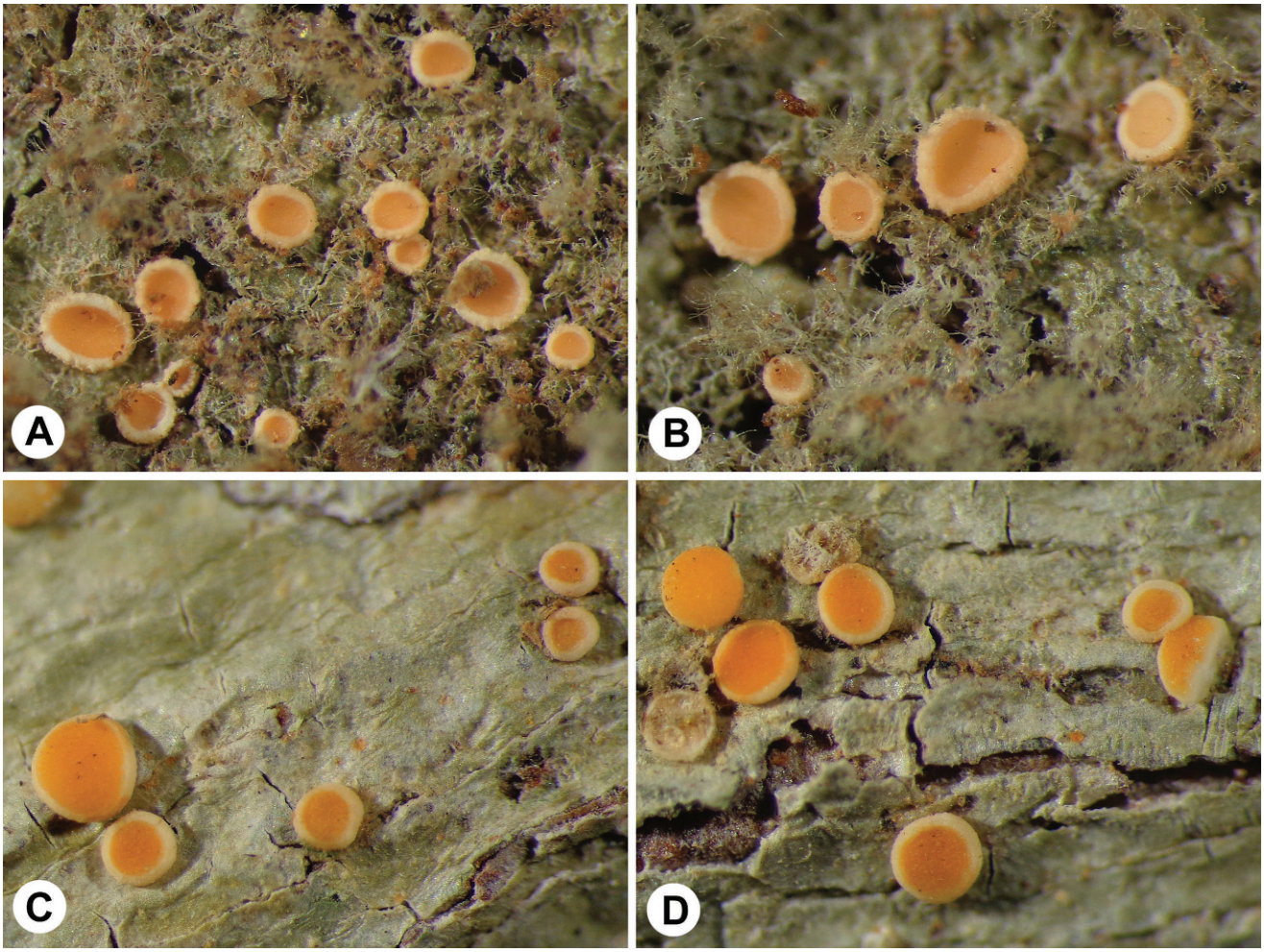

Figure 3. A–B. *Coenogonium dimorphicum* (holotype). **A.** Thallus with apothecia; **B.** Detail of apothecia. **C–D.** *Coenogonium portoricense* (holotype). **C.** Thallus with apothecia; **D.** Detail of apothecia.

young apothecia, rough to minutely denticulate, cream-colored to pale orange-yellow in old apothecia. Excipulum paraplectenchymatous with peripherally radiating cell rows, 60–100 µm broad, colorless, I–; cells isodiametric and thick-walled in inner parts, 3–5 × 3–4 µm, in peripheral parts radially elongated and partially thin-walled, 5–9 × 4–5 µm. Hypothecium 20–30 µm, colorless. Hymenium 60–70 µm, colorless, I+ blue then sordid blue-green. Asci 50–60 × 7–8 µm. Ascospores biseriate, narrowly ellipsoid to fusiform with rounded ends, 1-septate, 10–15 × 2.5–3.5 µm, 3.5–4.5 times as long as broad. Pycnidia not observed. Chemistry: no substances detected by TLC.

Distribution and ecology. Known from the well-developed type collection from a non-calcareous dry forest fragment within the former U.S. Naval Station Roosevelt Roads in the municipality of Ceiba, at 10 m altitude. It was found growing on living tree trunks under partly shaded conditions.

Discussion. *Coenogonium borinquense* is a rather nondescript species in lacking any conspicuous feature. However, it does not agree with any of the species treated in Rivas Plata et al. (2006). Ascospore size is intermediate between smaller- and larger-spored species. Among smaller-spored species, *C. saepincola* Aptroot, Sipman & Lücking comes close in apothecia morphology, but its thallus is whitish and its ascospores are much shorter (8–10 µm). Similar in ascospore length are *C. tavaresianum* Vězda Lücking, Aptroot & Sipman, *C. labyrinthicum* Lücking & Kalb and *C. aciculatum* Lücking & Aptroot (Lücking & Kalb 2001; Rivas Plata et al. 2006; Vězda 1969). The former, known from Portugal, has a rugose-verruculose thallus and brownish orange apothecia; both *C. labyrinthicum* and *C. aciculatum* have bright yellow (including the margin), larger apothecia and much narrower ascospores (1.5–2 µm broad).

Coenogonium dimorphicum Mercado-Díaz & Lücking, *sp. nov.* **Fig. 3A–B**

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Differing from other Coenogonium species in the combined crustose-filamentous thallus and the

apothecia emerging both from crustose and filamentous portions of the thallus.

Type: Puerto Rico. Municipality of Humacao, Barrio Candelero Abajo, Urbanización Palmas del Mar, Calle Palmeras; 18°05′34″ N, 65°48′06″ W, sea level; on trunk of tree; *Mercado-Díaz 863* (holotype: F; isotype: UPR); ibid., *Mercado-Díaz 865* (paratype: F, UPR).

Description. Thallus corticolous, dimorphic, basal thallus crustose, thin, smooth, pale greyish green, glossy, 2–5 cm diam., with cartilaginous corticiform layer, with erect cushions of interwoven filamentous portions covering most of the thallus, cushions dispersed to contiguous, up to 1 mm thick, forming irregular, arachnoid patches; prothallus indistinct. Photobiont *Trentepohlia*, in crustose portions cells angular-rounded, in irregular plates or groups or short threads, 5–10 µm diam., in filamentous portions cells rectangular, in distinct, branched filaments, 12–15 × 4–5 µm. Apothecia sessile on both the basal crustose (especially on the paratype) and the erect filamentous thallus, rounded, 0.4–1.0 mm diam. and 250–300 µm high; disc plane, pale salmon-orange; margin distinct, slightly prominent, minutely denticulate, cream-colored. Excipulum paraplectenchymatous with peripherally radiating cell rows, 70–150 µm broad, colorless except slightly yellowish along the outer margins, I–; cells isodiametric and thick-walled in inner parts, 3–7 × 3–5 µm, in peripheral parts radially elongated and thin-walled, 6–10 × 5–6 µm. Hypothecium 25–50 µm, colorless to pale yellowish. Hymenium 70–80 µm, colorless, I+ blue then sordid blue-green. Asci 60–65 × 5–6 µm. Ascospores more or less uniseriate, narrowly ellipsoid, 1-septate, 7–8 × 2–2.5 µm, 3–4 times as long as broad. Pycnidia not observed. Chemistry: no substances detected by TLC.

Distribution and ecology. Known from the well-developed type collection from an isolated *Pterocarpus* swamp within the urbanization Palmas del Mar in the municipality of Humacao, at sea level. It was found growing on living tree trunks under shaded conditions.

Discussion. This new species belongs in a small group of species with dimorphic thallus, consisting of a crustose basal thallus and an erect, filamentous portion; thus it is intermediate between the entirely filamentous species previously considered *Coenogonium* s.str. and the crustose species previously assigned to *Dimerella*, supporting the merging of these two genera (Lücking & Kalb 2000). Thus far, three species are known in this group: *C. ciliatum* Kalb & Lücking, with pilose apothecial margins, *C. epiphyllum* Vain., with smooth apothecial margins and straight ascospores, and *C. curvulum* Zahlbr., with smooth apothecial margins and curved ascospores (Lücking & Kalb 2000; Rivas Plata et al. 2006; Santesson 1952). All three have pale to bright yellow apothecial discs and mostly unbranched trichomes covering the entire thallus in regular fashion, and the apothecia are always sessile on the basal, crustose thallus. *Coenogonium dimorphicum* differs in several characters from the preceding species: the erect thallus forms irregular, arachnoid cushions; the apothecia are often sessile on the filamentous portions; the apothecial disc is pale salmon-orange, and the margin is minutely denticulate. Ascospores are very similar in all four species.

Coenogonium portoricense Mercado-Díaz & Lücking, *sp. nov.* **Fig. 3C–D**

Mycobank MB 805802

Differing from Coenogonium zonatum in the larger apothecia with deep orange disc.

Type: Puerto Rico. Municipality of Humacao, Barrio Candelero Abajo, Urbanización Palmas del Mar, Calle Palmeras; 18°05′34″ N, 65°48′06″ W, sea level; on trunk of tree; *Mercado-Díaz 864* (holotype: F; isotype: UPR).

Description. Thallus corticolous, crustose, continuous, thin, smooth, greyish green, glossy, 5–10 cm diam., with cartilaginous corticiform layer; prothallus white-grey, glossy. Photobiont *Trentepohlia*, cells angular-rounded, in irregular plates or groups or short threads, 5–9 µm diam. Apothecia sessile, rounded, 0.3–0.6 mm diam. and 200–250 µm high; disc plane, deep orange; margin distinct, not prominent, smooth, cream-colored. Excipulum paraplectenchymatous with peripherally radiating cell rows, 60–120 µm broad, colorless, I–; cells isodiametric and thick-walled in inner parts, 4–7 × 4–6 µm, in most peripheral parts radially elongated and partially thin-walled, 5–9 × 4–6 µm. Hypothecium 20–40 µm, colorless. Hymenium 60–70 µm, colorless, I+ blue then sordid blue-green. Asci 50–60 × 7–8 µm. Ascospores irregularly biseriate, narrowly ellipsoid to fusiform with rounded ends, 1-septate, 10–12 × 2.5–3.5(–4) µm, 3–4 times as long as broad. Pycnidia not observed. Chemistry: no substances detected by TLC.

Distribution and ecology. Known from the well-developed type collection from an isolated *Pterocarpus* swamp within the urbanization Palmas del Mar in the municipality of Humacao, at sea level. It was found growing on living tree trunks under shaded conditions.

Discussion. This species falls into a group with small, relatively broad ascospores. Species with more or less similar-sized apothecia and ascospores are *C. frederici* (Kalb) Kalb & Lücking, *C. subluteum* (Rehm)

Kalb & Lücking, and *C. zonatum* (Müll. Arg.) Kalb & Lücking & Kalb 2000; Rivas Plata et al. 2006; Santesson 1952). All have pale salmon-orange rather than deep-orange apothecial discs; *C. subluteum* and the Hawaiian *C. frederici* lack a prothallus, and the usually foliicolous *C. subluteum* also differs in the abundant pycnidia that are always present. The African, foliicolous *C. usambarense* (Vězda & Farkas) Lücking & Kalb has similarly colored apothecia as in the new species, but the apothecia are thinner and the ascospores narrower (2–3 μm). *Coenogonium nepalense* (G. Thor & Vězda) Lücking, Aptroot & Sipman differs in the yellow rather than orange apothecial disc and also in the narrower ascospores (2–3 μm).

In the key presented by Rivas Plata et al. (2006), the new species can be added as follows:

4b1 Erect filaments mostly unbranched, covering the entire thallus; apothecia always sessile on the basal, crustose thallus; apothecial margin smooth, disc pale yellow ..... ***C. epiphyllum***

4b2 Erect filaments branched and interwoven, covering portions of the thallus; apothecia sessile on both the basal, crustose thallus and on the erect filaments; apothecial margin minutely denticulate, disc pale salmon-orange ..... ***C. dimorphicum***

48c Thallus smooth; apothecia 0.2–0.5 mm diam.; disc pale orange-yellow; hymenium 60–70 μm; ascospores 10–15 × 2.5–3.5 μm, 3.5–4.5 times as long as broad ..... ***C. borinquense***

61b [emended] Disc wax-colored to pale or bright orange or salmon-colored 64

64a1 Disc pale orange to salmon-colored; thallus opaque, white prothallus absent ..... ***C. frederici***

64a2 Disc bright orange; thallus shiny, with glossy white-grey prothallus ..... ***C. portoricense***

80b [emended] Disc pale yellow to orange or yellow-brown 82

82c Disc and margin bright orange; margin rough; ascospores uniseriate ..... ***C. aurantiacum***

Discussion

With the species described in this study, a total of ten species of *Coenogonium* are now known from Puerto Rico (Harris 1989; Mercado-Díaz 2009), including the previously reported *C. interplexum* Nyl., *C. leprieurii* (Mont.) Nyl., *C. linkii* Ehrenb., and *C. subdilutum* (Malme) Lücking, Aptroot & Sipman. This is a comparatively small number, considering the 48 species reported for Costa Rica (Rivas Plata et al. 2006). The much lower number for Puerto Rico could be explained by a combination of fewer available forest habitats, taking into account that *Coenogonium* is mostly found in the shaded forest understory (Rivas Plata et al. 2008), and the fact that Puerto Rico is much closer to the northern limit of the tropical zone than Costa Rica. Indeed, from subtropical Florida only eight species of *Coenogonium* are known (Lücking et al. 2011). This indicates that most *Coenogonium* species are confined to the inner tropical zone immediately north and south of the equator.

Descriptions for *Coenogonium aurantiacum* and *C. portoricense* are based on single, yet well-developed collections. One should usually be careful in describing new species known from single collections, but we have opted to provide formal descriptions for these taxa for several reasons. Firstly, morphological variation in *Coenogonium* species is rather well-documented and characters such as color, surface structures and ascospore size are rather invariable in a given species as long as the collection is well-preserved and not damaged through inappropriate drying, as for example using heat or pressing wet specimens (Rivas Plata et al. 2006). Together with the fact that all of the type collections are well-developed, we are therefore confident that the taxonomically important characters can be satisfactorily assessed given the material. Secondly, the particular circumstances in which these collections were gathered, partly in small urban relict forest fragments that are highly likely to vanish, together with the often observed rarity and local distribution of particular species in this genus (Rivas Plata et al. 2006), makes it unlikely that further collections will be discovered within a reasonable timeframe, especially since all sites have been subject to extensive lichen surveys (Mercado-Díaz in prep.). Instead, we consider it of utmost importance to provide formal descriptions for these taxa in order to make known their presence in highly endangered ecosystems and to emphasize the need to catalogue biological diversity before it vanishes.

Both *Coenogonium dimorphicum* and *C. portoricense* were found in a small *Pterocarpus* forest stand inside the urbanization ''Palmas del Mar'' in the municipality of Humacao. This stand is about 37.56 acres in size and is completely surrounded by housing and other urban infrastructure (**Fig. 1C**). *Coenogonium borinquense* and *C. aurantiacum* were found in two non-calcareous, dry forest patches inside the lands of the former U.S. Naval Station Roosevelt Roads in the municipality of Ceiba. These patches are about 14.12 and 25.54 acres in size, respectively, and are surrounded by infrastructure related to previous military activities in the area (**Fig. 1E**). The presence of new lichen species potentially endemic to discontinuous forest fragments, which are representative of ecosystems with limited coverage on the island, has implications for the conservation of biodiversity. *Pterocarpus* wetlands are protected mostly because alterations to these habitats require permits which are issued and regulated by federal and local governmental agencies. However, there is no uniform national or local legislation that guarantees the protection of wetlands (Miller & Lugo 2009). Recent studies suggest

that the combined effects of land use practices and climate change may ultimately eliminate these wetland communities (Rivera-Ocasio et al. 2007). In the past, *Pterocarpus* wetlands were more widespread (Santiago-Valentín 2008); at present, they only occupy about 5% of their original extent, mostly due to the results of previous agricultural activities (Miller & Lugo 2009). Today, surviving *Pterocarpus* stands are restricted to the extreme of their physiological distribution in areas adjacent to mangroves, where they are susceptible to changes in hydrology (Eusse & Aide 1999). In this respect, increased salinity and flooding events due to climate change are expected to result in migration of these inland, but agricultural and urban land-use often dominate these inland areas, suggesting that unless restoration efforts are initiated, *Pterocarpus* stands may soon disappear from the natural landscape (Rivera-Ocasio et al. 2007).

Caribbean dry forests are among the least conserved of the tropical dry forests (Lugo et al. 2006). While most coastal dry forests in Puerto Rico occur in calcareous substrate, those on non-calcareous substrates are of highly discontinuous distribution (Gould et al. 2007) and have limited geographic range due to the poor representation of volcanic formations in dry environments of the island (Lugo 2005). Similar to *Pterocarpus* forests, these forests have also experienced landscape-scale transformations due to land use change (Lugo 2005). They are also disturbed by uncontrolled infrastructure development and the construction of urbanizations and garbage dumps in surrounding areas, which increases their vulnerability. Nevertheless, due to the limited availability of studies, the most worrisome threat to these forests is perhaps the lack of knowledge we have about their ecology (Lugo 2005).

The discovery of four new species of *Coenogonium* in Puerto Rico is significant not only with respect to knowledge about the island's biodiversity, but to the overall knowledge of tropical lichenology as well. Finding four new species in a relatively well-documented tropical genus (Rivas-Plata et al. 2006), all occurring in an insular setting, may challenge our current understanding about the evolution and biogeographical patterns of these organisms in island ecosystems. It has been long accepted that nonvascular cryptogams have wide distributions at the specific level and low degree of regional and local endemism (Elix & McCarthy 1998; Lücking 1997, 2001; Smith 1993; Wu & Mueller 1997). Our findings suggest a different perspective, where regional and local diversification patterns, at least for some groups of lichens at the specific level, may have a stronger similarity with trends observed for vascular plants in island environments (Takhtajan 1986). This is also shown by molecular studies of lichens long believed to include pantropical or even cosmopolitan species (Moncada et al. 2013; Rivas Plata et al. 2013). It can therefore be expected that for islands such as Puerto Rico, and especially for isolated oceanic islands, such as the Hawaiian Islands, the level of endemism is actually much higher than currently believed. Our findings also stand as evidence confirming the importance of documenting the diversity of organisms that are commonly neglected in biodiversity inventories, when in fact they may be more speciose than other groups of organisms in particular areas. For Puerto Rico, these observations are of considerable relevance and represent an important contribution to the knowledge of the Caribbean biodiversity hotspot (Myers 2000).

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