Entoloma medianox, a new name for a common species on the Pacific coast of North America

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Nomenclatural Novelties: C.F. Schwarz, Index Fungorum, 220, 2015

Abstract
The western North American taxon long referred to as *Entoloma bloxamii* or *E. madidum* is given a new name, *Entoloma medianox*, the Midnight Entoloma. Although it is macroscopically quite similar to some forms of those European taxa, it is microscopically, genetically, geographically, and ecologically distinct.

Background
The recent work of Morgado, Noordeloos, Lamoureux and Geml (2013) clarified species concepts of those *Entoloma* in Europe that produce large, bluish-capped fruitbodies. *E. bloxamii* was epitypified with Austrian material (M.E. Noordeloos 200442), and *E. madidum* was neotypified with material from the Netherlands (M.E. Noordeloos 2004030). Despite having been considered synonymous for many years, Morgado et al. found that *E. bloxamii* and *E. madidum* are indeed distinct, separable both by macro- and micro-morphology as well as by their DNA sequence. Largent referred the western North American taxon to *E. madidum* and later to *E. bloxamii*, but the very different ecologies and widely separated geographic ranges of those species caused many to view the application of European names in the Pacific states of North America with suspicion. A few early sequences from Californian material suggested that it was indeed distinct, and Morgado et al. (2013) later reached the same conclusion using a multigene phylogeny, but they lacked field experience with the western North American species, and stopped short of naming it. Genetic sequences independently obtained here agree with these findings, and in combination with morphological data, *E. medianox* is distinguished from the European taxa and described below.

Specimens examined:
Entoloma medianox sp. nov. C.F. Schwarz *UCSC-0340* (HOLOTYPE), **IF551099**, 22 Nov 2012, Fall Creek Flats, Santa Cruz Co., CA, USA;
Entoloma medianox (f. *eos)*, C.F. Schwarz *UCSC-0338*, GenBank KP852559, 4 Nov 2012, Smith Grade, Santa Cruz Co., CA, USA.
Paratypes: *UCSC-0341,* GenBank KP852558, 14 Mar 2014, near Biomedical Sciences Building, University of California Santa Cruz, CA, USA*, UCSC-0334*, 4 Nov 2012, Fall Creek Flats, Santa Cruz Co., CA, USA; *UCSC-0337*, coll. Noah Siegel, 10 Nov 2011, Willits, Mendocino Co., California, USA.
** all specimens deposited in the collections of the Ken Norris Center for Natural History, University of California at Santa Cruz.*

Nomenclature: *Entoloma medianocte* C.F. Schwarz (Index Fungorum 222) is based on the same holotype, refers to the same taxon, and is a junior synonym.

Etymology
The Latin *medianox* (midnight) refers to the commonly midnight-blue colored caps of mature fruitbodies. The proposed epithet for the pink-capped form refers to Eos, the Goddess of dawn. This is both intended as a counterpoint to 'midnight' of the nominate variety, as well as to indicate the rosy coloration of the cap (via classic Homeric simile "the rosy fingers of Dawn").

Fruitbody morphology
Cap 3-15 cm broad, rounded-convex when young, margin often inrolled, becoming broadly convex to plane, sometimes with a very low, round umbo, sometimes irregularly uplifted or wavy in age; very young fruitbodies buried in duff pale whitish-beige to cream colored, otherwise grayish-blue, sky-blue or powder blue, ranging through royal blue, but most typically dark grayish-blue to navy blue or midnight blue at maturity. At any age sometimes showing a narrow and contrasting whitish margin, and often with a pale silvery bloom over the center of cap. Occasionally irregularly pigmented with grayish-beige splotches and streaks. Surface nearly smooth to strongly wrinkled-rivulose, viscid to dry. **Gills** whitish to creamy at first, often with a pale blue wash near the margin, becoming pinkish as the spores mature. Sometimes entirely washed bluish. Usually notched, sometimes narrowly adnate, fairly close, edges often irregular, gills sometimes wavy. **Stipe** 6-10 cm tall, 1.5-3 cm thick. Whitish, developing sky-blue to grayish-blue tones, sometimes yellowish near the base. Club-shaped or cylindrical, sometimes tapered at base. Usually fairly robust, surface often with silky-silvery sheen and vertically-marbled appearance. Surface nearly smooth and usually with thin, appressed chevrons of silvery or whitish tissue. **Flesh** quite firm, solid, whitish or pale bluish (especially near cap surface). Bruising reactions absent. **Odor** indistinct. **Taste** indistinct. **KOH** reactions indistinct or sometimes weakly orangey-brown on cap. **Spore deposit** cinnamon-pinkish to salmon.

Habit and habitat
Fruiting singly or in large groups, sometimes in clusters. Most abundant in forest stands dominated by Coast Redwood (*Sequoia sempervirens*), or in mixed forests including Tanoak (*Notholithocarpus densiflorus*) and Madrone (*Arbutus menziesii*). In drier or inland areas and in the southern reaches of its range, it appears to fruit commonly under California Bay-Laurel (*Umbellularia californica*) and various live oaks (*Quercus* spp.), while north of California it apparently prefers Red Cedar (*Thuja plicata*), and possibly other trees in the Cupressaceae. Nowhere in the western United States is it regularly found in grasslands or meadows, unlike its European counterparts. Usually fruiting from mid-fall through early winter, generally most abundant from November through January. Although some species in this group are thought to be ectomycorrhizal, this species often occurs in pure stands of Coast Redwood, which does not form such associations.

Figure 1. All depicting *Entoloma medianox.* **A.** UCSC-0340 (Holotype); **B-D** additional specimens showing a range of cap colors including pale beige-grayish in young caps. **E**. UCSC-0341 (Genbank KP852558) **F**. Close up showing the rivulose texture of the cap surface. **G**. UCSC-0338 (Genbank KP852559) *E. medianox* f. *eos*: an aberrant hypo-pigmented form showing pink cap coloration.

Microscopy: Pileipellis a cutis of entangled, clamped hyphae embedded in a gelatinous matrix. Cystidia absent from lamellae and stipe surface. **Spores** 6.5–9 × 6-8.5 microns (averaging around 7.5 × 7.5 µm), with 5–6 sides, nearly isodiametric, fairly thick-walled, with a prominent hilar appendage (see Figure 3). Clamps present in all tissues. Basidia 4-spored.

Range

Examination of records on Mushroom Observer (hereafter referred to as MO), excluding some based on macro-morphology, yielded the following estimates of biogeographic range: North to southern British Columbia, apparently fairly rare in much of Washington and Oregon, collections likely pertaining to this species have been made on the coast and in the mountains (Beug and Kroeger, pers. comm.), but likely rare in inland montane areas, see (Aaron Cena's MO Observations 187794 and 151381 from ~700 m in the southern Cascades). Two collections from the mountains around Breitenbush, OR that may be referable to this species (deposited at UBC as PK 758, 28 Oct 1983 and PK 3422, 27 Oct 2000) should be examined. There are also specimens at SFSU from Tuolumne County and Yuba Pass (both identified by David Largent). This species becomes quite common starting around Del Norte and Humboldt counties in northern California, remaining so south along the 'fog belt' primarily with Coast Redwood into Monterey County. Likely occurs as far south as northern San Luis Obispo County - specimens photographed (but not collected) under California Bay-Laurel near Morro Bay are a good macroscopic match. However, the fruitbodies are slightly further towards the gray end of the range of variation of *E. medianox*, and without herbarium specimens the identification cannot be established beyond doubt. Although not known from Alaska, this species should be looked for in forests of Yellow Cedar (*Cupressus nootkatensis*) and Red Cedar (*Thuja plicata*) around the southeastern panhandle.

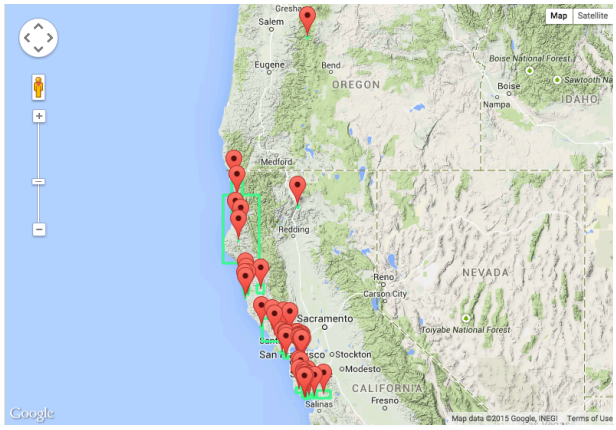

Figure 2. Incomplete range map showing core range. Markers shown are from Mushroom Observer (March 2015). Northern and southern extent not shown (see description above).

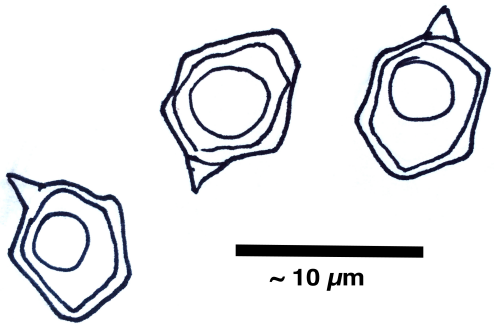

Figure 3. Spore morphology. Drawn from holotype specimens at 1000x.

Edibility
Although not commonly collected for the table, Arora (1986) knew it to be edible, and a number of individuals have eaten it without ill effects. Moderation is recommended due to the lack of historical experience with this species; cumulative risks are unknown, and likely to remain so.

Morphology, variation, and similar species
The cap color is notably pale in some young fruitbodies (near cream-tan or beige), but most mature caps above the duff are distinctly blue to blue-gray. Fruitbodies of *E. medianox* forma *eos* (confirmed to be conspecific by ITS barcode sequence) apparently do not produce the blue-gray pigments. In this form, the cap appears predominantly pale pinkish; it is illustrated in Figure 1-G above. Interestingly, a pinkish color variant of a member of this species group also occurs in Europe (*E. bloxamii* var. *rubellum*).

The extent of blue tones on the gills and stipe varies quite a bit. On many fruitbodies both gills and stipe are pure creamy-whitish, but just as commonly there are bluish or blue-gray tones present as well. Occasionally the gills and/or stipe are predominantly bluish. See Joe Soeller's MO Observation 195174 (but see notes on similar species below).

Singer states "veil none, or fugacious (traces of a cortina)" (1986) for the Entolomataceae, but the appressed chevrons of pale tissue on the stipe are quite consistently present even in young fruitbodies of *E. medianox*. They don't appear to arise from the stipe tissue itself, and the origin of this character is puzzling. A few photographs of Italian material (probably of *E. madidum* based on intensity and persistence of blue tones) available online show stipes covered in similar distinct and sometimes abundant silvery-whitish chevrons of tissue, though other photos of European material seem to lack this feature.

The European taxa are morphologically quite similar (although a person familiar with all the taxa involved would likely be able to distinguish them by a gestalt sense involving intensity of colors and stature), but are amply distinguished by a combination of ecology, spore size, and DNA sequence (see alignments against *"bloxamii-NA", bloxamii, madidum,* and *caesiolamellatum* referenced in Morgado et al 2013) at the end of this document).

Although there is a wide range of variation and overlap in spore dimensions of species in this complex, the average spore dimensions of *E. medianox* (~ 7.5 x 7.5) are smaller than those of *E. bloxamii* (avg. 8.2 × 8.3 µm), but larger than those of both *E. madidum* (6.8 × 6.7 µm) and *E. caesiolamellatum* (7.1 × 7.1 µm).

Similar species occurring along the Pacific coast of the United States are scarce. The vast majority of other blue *Entoloma* in the western United States are smaller and more slender. Large fruitbodies of *Entocybe nitida* have been confused for this species, but aside from being more slender, their spore morphology is also quite different, with more numerous facets. A few *Tricholoma* species in our area produce somewhat similar-

looking grayish-capped fruitbodies but have more distinctly sinuate gills that don't turn pink in age (remaining whitish), and less distinct blue tones in the cap.

At least one other taxon in this group is known from the California coast - although *Entoloma caesiolamellatum* is typified by material from the Canary Islands, Morgado et al. found that a collection made by Tim Baroni (TB6117) in Mendocino County is a good morphological match, as well as a preliminary genetic match for that species (but with low support). Distinguished by a consistent and extensive blue-gray hue to the gills, as well as by smaller average spore dimensions, such specimens may have been overlooked as normal variants of *E. medianox* at fairs and forays. Although one fruitbody in MO Observation 195174 has extensively pigmented gills, the other fruitbodies around it appear typical of *E. medianox*, and it probably represents inherent variation of that species. Specimens with less blue in the cap, and especially brownish-gray forms (such as those photographed by Trent Pearce in MO Observation 184249) should be vouchered and examined closely as they may very well represent additional taxa in this species group.

Alan Rockefeller's MO Observations 83346 from Colima and 103981 from Oaxaca (both Mexico) almost certainly represent additional undescribed taxa in this species group. Matt Sherman's MO Observation 57993 from North Carolina is intriguing, especially given the rarity of large, blue-capped *Entoloma* in this part of the country). Curiously, a taxon referred to *E. bloxamii* is also reported from North Carolina by Lincoff (1981).

Special thanks to MO users Trent Pearce, Joe Soeller, Alan Rockefeller, Matt Sherman, Aaron Cena, and Noah Siegel. Thanks to Michael Beug, Paul Kroeger, Kate Mohatt, Kitty LaBounty and Steve Trudell for providing information on the status of this species in the Pacific Northwest. Thanks to Ken-ichi Ueda, whose review made this a significantly better paper. Thanks also to Dr. Else Vellinga and Dr. Tom Volk for consultation on the Latin names (Dr. Vellinga also provided comments on the text), and to Dr. Pablo Alvarado for sequencing work. Extra-special thanks go to Joshua Birkebak, who reviewed the text and provided literally invaluable help with the GenBank submission process. Thanks to Adam Ryszka for introducing me to the type locality, as well as for hosting this paper at scmycoflora.org.

References

Arora D, 1986. *Mushrooms Demystified*. Ten Speed Press, USA.
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Lincoff G, 1981. *National Audubon Society Field Guide to North American Mushrooms*. Knopf, USA.
Morgado LN, Noordeloos ME, Lamoreux Y, Geml J, 2013. Multi-gene phylogenetic analyses reveal species limits, phylogeographic patterns, and evolutionary histories of key morphological traits in Entoloma (Agaricales, Basidiomycota). *Persoonia* 31, 2013: 159–178. (full text: www.ncbi.nlm.nih.gov/pmc/articles/PMC3904048/)
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Wilson, N., Hollinger, J. 2006-present. Mushroom Observer (mushroomobserver.org).

Pairwise alignments created using BLASTN 2.2.31+
Reference: Zheng Zhang, Scott Schwartz, Lukas Wagner, and
Webb Miller (2000), "A greedy algorithm for aligning DNA
sequences", J Comput Biol 2000; 7(1-2):203-14.

1) Entoloma medianox vs. reference ITS sequence of “Entoloma bloxamii-NA” sequence referenced in Morgado et al 2013:
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ribosomal RNA gene, complete sequence; and internal transcribed
spacer 2, partial sequence
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2) Entoloma medianox vs. reference ITS sequence of Entoloma bloxamii (Epitype) referenced in Morgado et al 2013:

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RNA gene, complete sequence; and internal transcribed spacer
2, partial sequence
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3) Entoloma medianox vs. reference ITS sequence of Entoloma madidum (Neotype) referenced in Morgado et al 2013:
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4) Entoloma medianox vs. reference ITS sequence of Entoloma caesiolamellatum (Holotype) referenced in Morgado et al 2013:

RID: FH70JRNW11N

Query= Entoloma medianox_14 March 2014_Santa Cruz, California_UCSC-0341_ITS 4

Length=688

                                                                      Score     E
Sequences producing significant alignments:                          (Bits)  Value

Query_163959  gi|531247705|gb|KC710126.1| Entoloma sp. LNM-201...  392     3e-113

ALIGNMENTS
>lcl|Query_163959 gi|531247705|gb|KC710126.1| Entoloma sp. LNM-2013a strain 626
internal transcribed spacer 1, partial sequence; 5.8S ribosomal
RNA gene, complete sequence; and internal transcribed spacer
2, partial sequence
Length=761

 Score = 392 bits (212),  Expect = 3e-113
 Identities = 296/335 (88%), Gaps = 11/335 (3%)
 Strand=Plus/Minus

Query  69   AATGGTATAGATAA-TTTATCAACACCAAA-CTGATTTGTTAGGCAAATGTTCT-GCTAA  125
            ||||| |||||||| ||||||||||||||   | | |   ||  ||| ||| | |||||
Sbjct  634  AATGGCATAGATAACTTTATCAACACCAAAAGGGCTATTCCAGCAAAAGGTTTTGGCTAA  575

Query  126  TATATTTAAGAAGAGCTGACTTT-TGAAGAAGCCTGCAAACTCCCATAAATCCAA-CCCA  183
            || |||||||||||||||||| | ||||||||||||| ||||||||| ||||| |||
Sbjct  574  TACATTTAAGAAGAGCTGACTTTGTCAAGAAGCCTGCAACCTCCCATAA-TCCAATCCCT  516

Query  184  GACTAGCCATTCAAGAAAATAGCTAGAAAGGTTTGATAATTTCATGACACTCAAACAGGC  243
            ||||||  | |  | |||||| ||||||| | |||| ||||||||||||||||||||||
Sbjct  515  GACTAG--A-TATATAAAATAACTAGAAAAGATTGAGAATTTCATGACACTCAAACAGGC  459

Query  244  ATGCTCTTTGGAATACCAAAGAGCGCAAGGTGCGTTCAAAGATTCGATGATTCACTGAAT  303
            |||||||| |||||||||| ||||||||||||||||||||||||||||||||||||||||
Sbjct  458  ATGCTCTTCGGAATACCAAGGAGCGCAAGGTGCGTTCAAAGATTCGATGATTCACTGAAT  399
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Query  304  TCTGCAATTCACATTACTTATCGCATTTCGCTGCGTTCTTCATCGATGCAAGAGCCAAGA  363
            ||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||
Sbjct  398  TCTGCAATTCACATTACTTATCGCATTTCGCTGCGTTCTTCATCGATGCAAGAGCCAAGA  339

Query  364  AATCCATTGTTGAAAGTTGTATTAATTTATTTAAA  398
             |||||||||||||||||||| |  ||| ||||||
Sbjct  338  GATCCATTGTTGAAAGTTGTACTT-TTT-TTTAAA  306


 Score = 148 bits (80),  Expect = 8e-40
 Identities = 122/141 (87%), Gaps = 7/141 (5%)
 Strand=Plus/Minus

Query  521  GTCTACAAAAGTTCACAAGTGGTTATGGGTTTTAAATGTTCAGGTGTGCACATATATCCC  580
            |||||||||||| ||||||||||  |  | ||| ||||   || |||||||  || |||
Sbjct  142  GTCTACAAAAGTGCACAAGTGGTGCT-TG-TTT-AATG-CAAGATGTGCAC--ATGTCCT  89

Query  581  TAAGGACCAGCAACAACCCAAGCAAGTTTAATTCTATAATGATCCTTCCGCAGGTTCACC  640
            ||||||||||||||||||  ||||||| |||| ||||||||||||||||||||||||||
Sbjct  88   TAAGGACCAGCAACAACCCAGCCAAGTTT-ATTCAATAATGATCCTTCCGCAGGTTCACC  30

Query  641  TACGGAAACCTTGTTACGACT  661
            |||||||||||||||||||||
Sbjct  29   TACGGAAACCTTGTTACGACT  9
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