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First record of the moon jellyfish, *Aurelia* for Chile

(Scyphozoa: Semaeostomeae)

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The scyphozoan genus *Aurelia* has been recorded as occurring circumglobally between 70°N to 55°S. However, it has not been reported from the Pacific coast of South America. Here, we describe the occurrence of *Aurelia* in the fjords of Chile and use morphology and a simple "DNA barcoding" sequence similarity comparison to identify the species as most probably *A. aurita*. This species likely is not indigenous to this region.

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Introduction

The moon jelly, *Aurelia*, is the best studied and best known genus of scyphomedusae. *Aurelia* is one of the most widely distributed scyphozoan genera, ranging from 70 °N to 55 °S (Dawson & Martin 2001). It is also a common research subject (Arai 1997), probably the most common scyphozoan displayed in aquaria, and also economically important because it preys on or competes with larvae of commercial fisheries (Möller 1980) and its mass occurrences may present problems for trawlers or power-plant intakes (Mills 2001).

Due to uncertainty in systematic interpretation of morphological variation, estimates of species diversity within the genus *Aurelia* declined almost ten-fold during the 1900's. By the last quarter of the 20th century just two species were recognized: *Aurelia aurita* and *A. labiata* (Kramp 1968, see also Arai 1997, Russell 1970). However, subsequent morphological and DNA analyses revealed at least 16 phylogenetic species of *Aurelia* (Dawson & Jacobs 2001, Gershwin 2001, Schroth et al. 2002, Dawson et al. 2005), nine of which are found only in specific areas within the Pacific Ocean. These data showed that *Aurelia* species are more ecologically and morphologically variable and more regionally restricted than previously thought (Dawson & Martin 2001, Schroth et al. 2001, Dawson 2003). For example, the type species *A. aurita*, which for much of the 1900's was considered a wide-spread, ecological generalist (Russell 1970, Kramp 1961), is in fact restricted to the boreal Atlantic Ocean and northern European seas (Mills 2001, Dawson 2003). As if for emphasis, the now exceptionally broad geographic occurrence of *Aurelia* sp. 1, is demonstrably the result of anthropogenic species introduction from Japan into Australia, California, and France (Greenberg et al. 1996, Dawson et al. 2005).

Here, we present the first record of a member of the genus *Aurelia* from the South East Pacific. We use a simplistic "barcoding" sequence similarity comparison to assess the taxonomic and biogeographic affinities of these medusae and, therefore, whether the species is likely endemic or introduced.

Fig. 1. Sampling sites in the Chilean fjord region. △, sampled sites. ▲, sites where polyps were found. ○, sites where medusae were found.

Material and Methods

Since 1998, surveys of the benthic and bentho-pelagic fauna have been carried out in the Chilean fjord region between Puerto Montt (~41°30'S) and the Straits of Magellan (~56°S) by Verena Häussermann and Günter Försterra. Several hundred dives have been made at more than 150 sites down to 40 m depth. Scyphozoan medusae were photographed but were not collected; polyps were collected and preserved in 4 % formalin and 96 % ethanol.

Morphological characteristics of the medusae were examined using photographs taken in situ. These were compared with descriptions of known species to provide a preliminary species identification.

Genomic DNA was purified, cytochrome *c* oxidase subunit I (COI) amplified, and the amplicon directly sequenced following the protocols of Dawson (2005). The sequence was then identified using a GenBank non-redundant *megablast* search for highly similar sequences and *blastn* search for somewhat similar sequences (http://blast.ncbi.nlm.nih.gov/Blast.cgi). An unweighted maximum parsimony analysis was conducted by Michael Dawson to confirm the phylogenetic affinity of the sequence.

Results

In March 2005 and March 2006, during two expeditions to the remote fjords and channels of the Central Patagonian Zone (CPZ; Golfo de Penas, approx. 47-48 °S to Straits of Magellan, approx. 56 °S) between 47°58'45.4" °S and 49°08' °S (see Fig. 1 and Tab. 1), VH and GF observed both medusae and polyps (Fig. 2A-C) of a scyphozoan. One and two medusa, respectively, were observed in the upper 15 m of two different localities along the Messier Channel (48°58'29" S; 74°25'16.9" W and 49°08' S; 74°25' W °S) (Fig. 2A). The temperature at these sites was 8 °C (surface and 20-30 m); salinity varied between 18–20 ‰ (surface) and 26-28 ‰ (20-30 m). Polyps with diameters of 1-3 mm were found at eight sites between 15 m and 30 m depth (with one exception, at ~10 m) in channels as well as in fjords that are strongly influenced by glacial sediment (Fig. 2B,C). Water temperatures where polyps were found varied between 6 and 13 °C (surface, in the low salinity layer) and 8 and 14 °C (15-25 m), salinities between 3 and 24 ‰ (surface, in the low salinity layer) and 15-30 ‰ (10-30 m). The polyps are among the few organisms that support a layer of fine sediment on the rock but generally live on vertical and overhanging walls, where there is not such a heavy sediment load; in some places they densely covered areas up to several square meters. Polyps also were observed growing on algae overgrown by hydrozoans and on the shells of brachiopods *Magellania venosa* and *Terebratella dorsata*.

Medusae between approx. 5 and 15 cm diameter were identified as members of genus *Aurelia* based on their characteristic morphology (Fig. 2A). Examination of this photograph shows complete or almost complete circular gastric filaments and gonads, eight marginal lobes, simple canal structure with few anastomoses within interradial or perradial

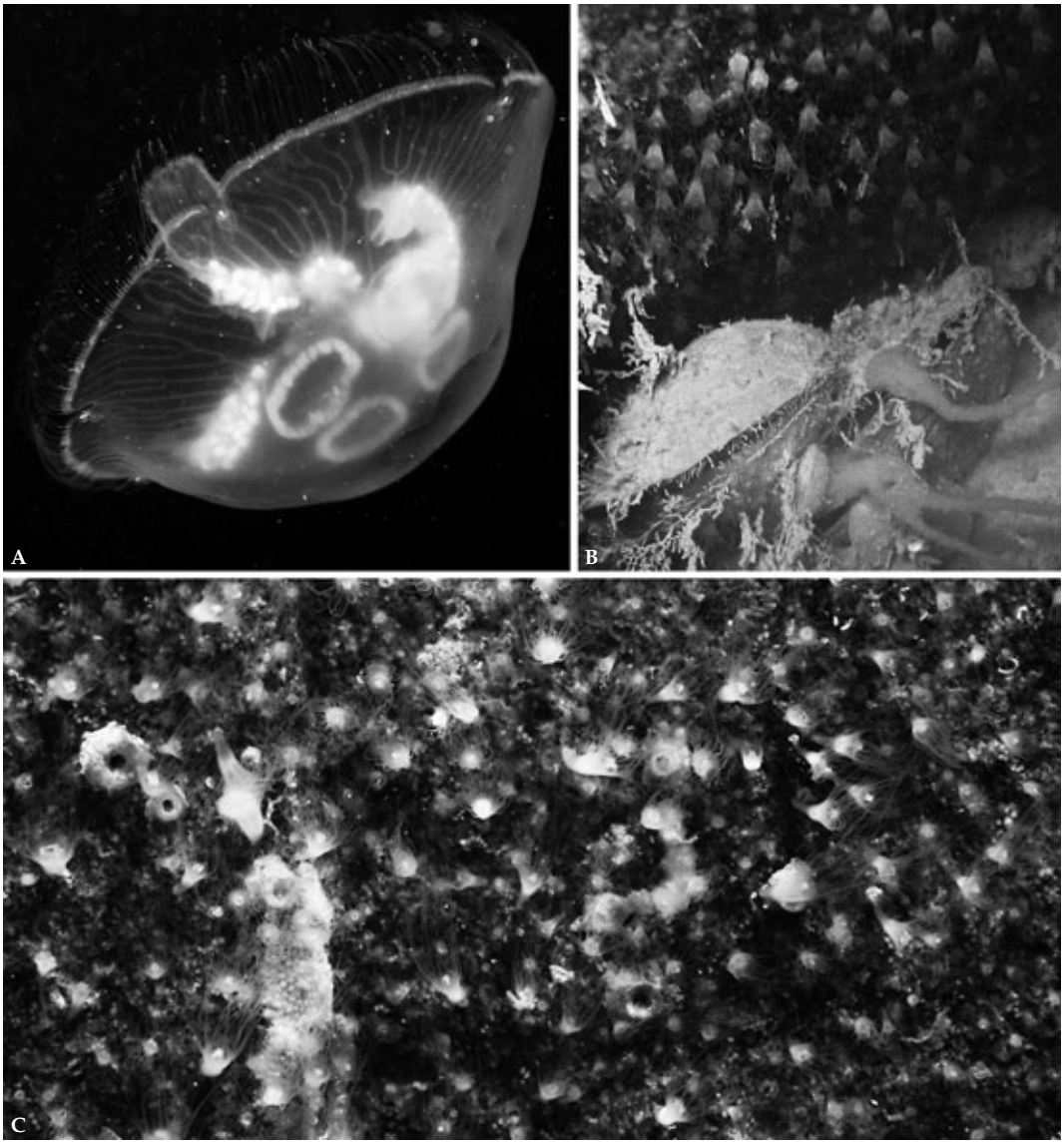

Fig. 2. *Aurelia* medusae and polyps. **A.** *Aurelia* medusa; bell diameter approx. 15 cm. Puerto Eden (C14), 10 m. **B, C.** *Aurelia* polyps; Size approx. 1-3 mm oral disc diameter. **B.** Tempano fjord (C1), 25 m; **C.** Isla Millar (D17), 23 m.

canal systems, and all visible adradial canals being unbranched. These character states are consistent with those shown by *A. aurita* (Russell 1970).

The *megablast* and *blastn* comparison of COI DNA sequence data (Fig. 3) both returned *Aurelia aurita* sequences as the most similar (E-value 0.0 to 0.0, 98-99 % sequence identity [12 matches], c.f. $2 \cdot 10^{-178}$ to $3 \cdot 10^{-117}$ and 84-85 % sequence identity with other species of *Aurelia* [11 matches, *Aurelia* sp. 6, *Aurelia labiata*, *Aurelia* sp. 10], and $\geq 3 \cdot 10^{-106}$ and ≤79 % sequence identity with other cnidarians). The *blastn* search returned 100 matches, all *Aurelia*. The highest sequence similarity was with *A. aurita*, 98-99 % sequence identity, compared with ≤86 % sequence identity with any of the other species of *Aurelia*. The phylogenetic analysis showed the query sequence was nested among previously published sequences for *A. aurita* (results not shown). Thus, the medusae and polyps were identified as *A. aurita*.

ATATTTGGTGCTTTTTCCGCCATGGTGGGAACTGCCTTCAGTATGATTATAAGACTGGAACTATCAGGCCCAG-
GATCCATGTTGGGGGACGATCAACTATATAACGTTGTAGTAACCGCTCATGCTCTTATAATGATTTTCTTTTTCG-
TAATGCCCGTTTTGATAGGGGGATTTGGAAACTGGCTAGTTCCCCTATATATAGGAGCTCCAGATATGGCCTTTC-
CAAGGCTTAACAATATCAGTTTCTGATTATTACCTCCAGCTTTATTACTATTATTAGGGTCTTCCCTTATAGAACAA-
GGAGCAGGTACTGGTTGAACCATTTACCCTCCTTTAAGTTCAATACAAGCTCATTCTGGGGGTTCAGTAGATAT-
GGCCATATTTAGTCTTCATTTAGCAGGAGCTTCCTCTATTATGGGTGCTATTAACTTTATTACCACTATTTTAAATAT-
GAGGGCCCCTGGTATGACCATGGATAGAATACCTTTGTTCGTATGATCTGTATTAGTTACTGCAATCTTATTATTGTT-
GTCCTTACCCGTATTAGCTGGGGCAATTACCATGTTGTTGACTGATAGAAATTTCAACACATCCTTCTTTGACCCT-
GCTGGGGGAGGAGATCCAATACTA

Fig. 3. *Aurelia* COI sequence amplified from a polyp collected at site D19. Specimen identification is MND177_Chile, GenBank Accession FJ858784.

Discussion

Both morphological characteristics and mitochondrial DNA sequence data are commensurate with identification of the medusae and polyps from site D19 as *Aurelia aurita* (e. g. Russell 1970). Considering the regionally restricted natural dispersal tendency of *Aurelia* (Dawson et al. 2005), it is highly unlikely to have colonized southern Chile naturally from the North Atlantic or northern Europe and therefore is best inferred to be an introduced species. Notably, sea surface salinities and temperatures are very similar in the invaded range in Chile and in possible source areas such as the North Sea and Baltic Sea (see e. g. Schroth et al. 2002). Environmental temperature is also a conserved feature of the source and invaded ranges of *Aurelia* sp. 1 (see Schroth et al. 2002, Dawson et al. 2005).

The occurrence of invasive *A. aurita* in the Messier Channel, but apparently not in large ports such as Puerto Montt (41°30'S) at the northern limit of the fjord region and Punta Arenas in the Straits of Magellan (56 °S), both only approx. 800 kilometers away (by sea; Fig. 1), is somewhat perplexing. These ports, like others in the world, must contain substrate suitable for settlement by scyphopolyps, and their water temperatures are comparable with those in the Messier Channel. Moreover, Puerto Eden (approx. 49 °S; less than 300 inhabitants), one of two small towns in the region where *A. aurita* occurs (the other is Tortel, approx. 47 °S; less than 400 inhabitants), is visited twice a week by a ferry that oscillates between Puerto Montt and Puerto Natales (~51°40'). Yet, the areas of Puerto Montt and Punta Arenas are well-studied relative to the CPZ and were visited by numerous larger expeditions (see e.g. Häussermann & Försterra, 2005), so we consider *Aurelia* most probably truly absent from these sites.

We hypothesize that there may be several mechanisms that cause or contribute to the failure of non-indigenous *A. aurita* to extend beyond the CPZ. One is that Puerto Eden village has no real harbour, the ferry is loaded and unloaded only to and from other boats, so the hull may not be sufficiently proximate to suitable substrate for colonization by polyps that might become dislodged or by swimming planuloids. Two, the ferry uses only solid ballast, so ballast water is not an issue. Three, although the Strait of Magellan and the Messier Channel are main shipping routes, traffic diminished since the construction of the Panama Canal in 1914. Four, ships mostly offload cargo at these Chilean ports, thus tend to take on seawater ballast here, as opposed to offload it (even though most exchange should occur

Table 1. Locations at which *Aurelia* medusae were seen and/or at which scyphopolyps were recorded. Collections for molecular analyses were made at site D19.

Site	Coordinates	Date	Specimens found
Punta al W de Estación Tempano (C1)	48°42'59.7"S, 74°00'18.8"W	24.03.2005, 26.03.2005	Polyps
Fjord Tempano, 16 km, S shore (C4)	48°42'50"S, 74°11'02.7"W	25.03.2005	Polyps
Fiordo Bernardo, 12 km, S shore (C6)	48°29'37.4"S, 74°05'02"W	27.03.2005	Polyps
Entrance Seno Farquhar (C8)	48°29'18.7"S, 74°12'25.7"W	29.03.2005	Polyps
Angostura Inglesa (C13)	48°58'29"S, 74°25'16.9"W	01.04.2005	1 medusa
Puerto Eden: Isla San Pedro (C14)	49°08'S; 74°25'W	01.04.2005	2 medusae
Isla Lavinia ILA (D12)	49°00'48.1"S, 74°58'37.5"W	13.03.2006	Polyps
Seno Waldemar SWA (D16)	48°23'48.5"S, 74°43'48.8"W	15.03.2006	Polyps
Isla Millar IMI (D17)	47°58'45.4"S, 74°40'47.0"W	15.03.2006	Polyps
Paso de Isla Ofhidro PIS (D19)	48°20'58.5"S, 74°11'41.8"W	16.03.2006	Polyps

offshore; http://www.imo.org/TCD/mainframe.asp?topic_id=867). This raises an interesting possibility that may explain the peculiar distribution of non-indigenous *Aurelia*. Site C 13, Angostura Inglesa (English Narrow) in the Messier Channel (the main channel N-S, D17 to C13, C14 and further south) is a particularly narrow passage that can only be used by large vessels twice a day, for 1-2 hours each time. We speculate that perhaps large vessels may offload ballast in close proximity to the narrows before this transit, increasing the chance of introduction into this sheltered area with abundant habitat. Further collections are required to confirm the extent of the introduced range of *A. aurita* along the Pacific coast of South America

Acknowledgements

We thank Nat Evans and the Cnidarian Tree of Life Project (USA National Science Foundation grant EF-0531779; http://cnidarian.info/) for undertaking the molecular analyses. Work on this project by MND was supported in part by grant DEB-0717078 from the US National Science Foundation to MND and Allen Collins. This is publication nr. 40 of Huinay Scientific Field Station.

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Buchbesprechungen

1. Moritz, G.: Thripse. Fransenflügler, Thysanoptera – Pflanzensaugende Insekten, Bd. 1 – Die Neue Brehm-Bücherei. Bd. 663, 334 pp., Westarp Wissenschaften, Hohenwartsleben, 2006, ISBN 3-89432-891-6.

Dieses umfangreiche Buch enthält alles Wissenswerte über eine recht kleine, wenig bekannte, aber nicht unwichtige Gruppe sehr kleiner Insekten, die Thripse oder Fransenflügler. Abgesehen von sehr ausführlicher Information über Morphologie, Phylogenie, Entwicklung, und Verhalten erfährt man sehr viel über ihre Biologie, darunter auch viel Neues und bisher Unbekanntes. Fransenflügler, so klein sie auch sind, gehören dennoch zu den wichtigen Schädlingen an Kulturpflanzen, können aber auch in Gewächshäusern und an Zimmerpflanzen schädlich werden. Wie das mit sehr kleinen Organismen häufig ist, übersieht man sie gern. Doch die Landwirtschaft übersieht diese Tier durchaus nicht, denn nach Schätzungen verursachen Fransenflügler jährlich einen Schaden von etwa 1 Milliarde US-Dollar. Daher enthält das Buch auch mehrere ausführliche Kapitel über Thripse als Schädlinge, ihre Bekämpfung, Zucht und Laborhaltung. Doch auch die positive Rolle der Fransenflügler, etwa als Bestäuber verschiedener Pflanzen wird beleuchtet. Die systematische Stellung der Familien wird dargestellt und eine beträchtliche Anzahl mitteleuropäischer Arten wird ausführlich beschrieben. Auf die Möglichkeit molekularer wie visueller Bestimmungsmethoden wird hingewiesen und ein reich bebilderter Bestimmungsschlüssel erlaubt die Bestimmung der wichtigen bei uns vorkommenden Schädlinge. Ein ausführliches Literaturverzeichnis, Register für Begriffe und für die Namen der im Text genannten Taxa, sowie ein Glossar beschließen dieses Buch. Es ist ein enorm ausführliches, fakten- und detailreiches Werk, das sämtliche die Thysanopteren betreffende Fragen behandelt und dem Leser eine Fülle von teils neuen Informationen vermittelt. Daher wendet es sich an eine Vielzahl von Benutzern, Entomologen, im Pflanzenschutz Tätigen, aber auch allgemein Interessierten, und kann diesem Leserkreis nur ausdrücklich empfohlen werden.

M. Baehr

2. Wildermuth, H.: Die Falkenlibellen Europas. – Die Neue Brehm-Bücherei. 496 S., ISBN 3-89432-896-7, WV Westarp Wissenschaften, Hohenwarsleben, 2008.

Die Falkenlibellen oder Smaragdlibellen (Coduliidae s. l.) gehören sicher zu den auffälligen Vertretern der Großlibellen, und auch ihre Lebensräume, wie etwa Moore, Moorseen im Gebirge und Flüsse im Flachland vor allem im mediterranen Raum werden durch sie mit charakterisiert. Die große Kenntnis des Autors spiegelt sich in der besonders großen Informationsfülle wider, die dieses Buch enthält, zumal es sich nur um 11 Arten dieser Familie in Europa handelt. Vom Ei über die Larve bis hin zum geschlechtsreifen Tier nach der Reifung, die meist abseits vom Gewässer stattfindet, werden die anatomischen Gegebenheiten, die Sinnesleistungen, die Physiologie, das Verhalten und die ökologischen Ansprüche behandelt. Dabei werden vielfach allgemein biologische Phänomene in einer ausführlichen Weise beschrieben, die der interessierte Leser in dieser Form nicht erwartet und die auch über den Rahmen einer Einführung in die Libellenbiologie hinausgehen. Die vorliegende Monographie der Corduliidae, wobei deren Monophylie vielfach angezweifelt wird und sich diese Gruppe auf Grund neuerer Bearbeitungen in Auflösung befindet, wird mit den Kapiteln zu den 11 Arten abgeschlossen, wobei noch die Art *Somatochlora graeseri* Selys, 1887, hinzugesellt wird, da diese ostpaläarktische Art im europäischen Teil des Ural entdeckt wurde. Ebenfalls hinzugefügt wird die Geschichte zu einer bis heute dubiosen Art, deren Entdeckungsgeschichte der Autor miterlebte. Das besonders umfangreiche Literaturverzeichnis belegt die Einbeziehung der zahlreichen Untersuchungen zu dieser Insektengruppe.

Ernst-Gerhard Burmeister

3. Wermelinger, B., B. Forster & J.-D. Godet: Borkenkäfer. Alle forstlich wichtigen Rinden- und Holzbrüter. – Godet Naturführer. – Eugen Ulmer KG, Stuttgart, 2007, 64 pp., ISBN 978-3-8001-5571-2.

Dieses schmale Büchlein ist eigentlich ein Bildband, der die 17 wichtigsten mitteleuropäischen Borkenkäfer behandelt. Die wichtigsten deshalb, weil es sich eben um die wichtigsten Holz- und Forstschädlinge unter den zahlreichen bei uns vorkommenden Arten handelt. Borkenkäfer haben ja in den letzten Jahren mehrfach das Interesse der breiten Öffentlichkeit geweckt, als sogenannte Borkenkäferkalamitäten und die Methoden zu ihrer Bekämpfung bzw. Vorbeugung auch in der Öffentlichkeit diskutiert wurden.

Eine kurze Einleitung behandelt die Biologie der Borkenkäfer, ihre wirtschaftliche und ökologische Bedeutung, die wichtigsten Feinde, und ihre Bekämpfung. Dann folgen die einzelnen Arten, beginnend mit dem Buchdrucker, der am besten bekannten und auch schädlichsten Art. Auf jeweils einer Doppelseite werden die Arten kurz beschrieben und charakterisiert und mit mehreren großenteils vorzüglichen Fotos vorgestellt. Die Fotos zeigen in der Regel den erwachsenen Käfer, wichtige zur Bestimmung notwendige morphologische Merkmale, und ein oder mehrere Fraßbilder. Ebenfalls jeweils eine Doppelseite ist den wichtigsten Wirtsbaumarten gewidmet, die beschrieben und als gesamter Baum sowie mit ihrer Rindenstruktur abgebildet sind. Ein Register beschließt dieses kleine, aber sehr informative Bändchen, das sowohl dem Forstmann und dem Entomologen als auch dem interessierten Laien eine Hilfe ist, der etwa wissen möchte, was es mit den seltsamen Mustern auf liegenden Baumstämmen für eine Bewandtnis hat.

M. Baehr