

Sea slugs of Peru: Peruvian-Chilean faunal elements

(Mollusca, Heterobranchia)

Michael Schrödl & Yuri Hooker

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The Peruvian marine invertebrate fauna is thus far poorly investigated referring to sea slugs. From recent surveys along the entire Peruvian coast we present new distributional data on those 15 benthic opisthobranch gastropod species that were formerly known from Chilean waters. Our findings include 12 nudibranch, 1 cephalaspidean and 2 sacoglossan species. These are the first records for Peru of 7 species, such as *Janolus rebecca* and *Hancockia schoeferti*. Known distributional ranges are extended to the north for 9 species, in case of *Polycera priva* for more than 3000 kilometres; the latter was formerly considered as a Magellanic species endemic to southern Chilean fjords. Photographs of living specimens as well as descriptions of habitats and biological observations are given. We also present the first record of splanchnotrophid copepods from Peru, infesting the aeolid nudibranch *Phidiana lottini*. Some further data and discussions are provided for species with insufficient or disputed information available.

Michael Schrödl, SNSB – Zoologische Staatssammlung München, Münchhausenstr. 21, 81247 München, Germany; e-mail: michael.schroedl@zsm.mwn.de

Yuri Hooker, Laboratorio de Biología Marina, Facultad de Ciencias y Filosofía, Universidad Peruana Cayetano Heredia, Lima, Peru

Introduction

Peruvian coastal waters can be roughly divided into three sections: 1) the northernmost part north of 4°S, which is steadily influenced by tropical waters, 2) a narrow transitional section (approx. 4–6°S) between tropical and temperate waters, and 3) a large zone south of 6°S, which is dominated by the temperate Peru current (Humboldt current). The latter area shows frequent cold water upwellings in normal years, but also periodical El Niño events with warm northern waters, poor in nutrients and oxygen, expanding towards the south (Arntz & Fahrbach 1996). According to these current regimes, the marine coastal fauna of northernmost Peru is largely Panamanian, while the region from approx. 6°S (Peru) to 41°S (southern Chile) hosts a fauna that is adapted to temperate conditions, and was considered as

the Peruvian faunal province (Tarazona et al. 2003, Hooker 2009). The South American coast south of roughly 41°S on both the Pacific and Atlantic sides comprises the Magellanic (or Magellan) province, of which the fauna of the Chilean fjord area recently has received considerable survey activity (see Häussermann & Försterra 2009). There are several reviews on Magellanic opisthobranch gastropods (Marcus 1959, Schrödl 1996a, 2003, 2009). Bergh (1898) described a couple of new opisthobranch species from central and northern Chile and limited knowledge on opisthobranchs from the Chilean part of the Atacama Desert coast was summarized by Schrödl (2003). The coastal sea slug fauna of nearby Peru was even less explored, and still may be among the poorest known on a global scale.

Older faunal studies include D'Orbigny (1835–47), who described several opisthobranch species

from Callao, central Peru, and Dall (1909), who described Peruvian shells. Faunal lists such as those by Álamo & Valdivieso (1987) and Paredes et al. (1999) summarized historical records of Peruvian opisthobranchs, however, including several unsubstantiated records, as noted by Uribe et al. (2013). Based on collected specimens, Millen et al. (1994) described *Okenia luna* Millen, Schrödl, Vargas & Indacochea, 1994 as a new nudibranch species from Chile and Peru. Revising the Chilean and Magellanic nudibranch fauna, Schrödl (2003) reported *Flabellina* sp. 2 (found by S. Millen) also from Peru; this species likely refers to *Flabellina cerverai* Fischer, Van de Velde & Roubos, 2007, which was established on Chilean specimens by Fischer et al. (2007). Nakamura (2006) first reported several Panamanian species from northernmost Peru, Martynov et al. (2011) described the new species *Corambe mancorensis* Martynov, Brenzinger, Hooker & Schrödl, 2011, and Jörger et al. (2012) reported the morphologically cryptic acchlidian *Pontohedyle* sp. The latter was described as a new species *P. yuriihookeri* Jörger & Schrödl, 2013 based mainly on evidence from gene sequences recently (Jörger & Schrödl 2013). In southern Peru, Uribe & Pacheco (2012) discovered specimens externally resembling the Atlantic nudibranch *Spurilla neapolitana*, a name which rather referred to a species complex (Carmona et al. 2013). Recently, Carmona et al. (2014) assigned Peruvian *Spurilla* specimens to *Spurilla braziliana* MacFarland, 1909, showing a wide Western Atlantic and Pacific distribution and occurring in tropical and temperate waters.

Molecular results of Ornelas-Gatdula et al. (2012) showed that Peruvian and other Eastern Pacific *Navanax aenigmaticus* specifically differ from their Atlantic sibling species. Pruning unsubstantiated literature records and adding 3 new own records of nudibranchs in their review, Uribe et al. (2013) considered 56 opisthobranch species (2 Acteonoidea species, 23 Nudibranchia, 27 Euopisthobranchia, 3 Sacoglossa and 1 Acochlidia) as valid for Peru. Uribe et al. (2013) emphasized the need of revision of Peruvian *Aplysia* species and thecosomes, the need of molecular surveys to recognize potentially cryptic species, and the strong need for further collectings along the Peruvian coast. In particular, many species already known from central or northern Chile (Schrödl 2003) might be suspected to extend more or less far north into the temperate regions of Peru, thus augmenting the species diversity.

During our own recent expeditions we collected benthic opisthobranchs along the entire Peruvian coast. On longer terms, together with a multinational team, we attempt to revise the Peruvian opisthobranch fauna and its evolution as a whole. It should be mentioned that here we use “opisthobranchs” as a descriptive term for euthyneuran marine slugs and snails, while decisively abandoning the traditional taxon “Opisthobranchia”, which was shown to be polyphyletic and reclassified (e.g. Jörger et al. 2010, Schrödl et al. 2011, Brenzinger et al. 2013); for a recent review see Wägele et al. (2014).

Herein we focus on reporting those findings of opisthobranch species in Peru that were already

Table 1. Collecting data; range extensions and species new for Peru in bold.

Localities	San Juan de Marcona	Laguna Grande	Paracas	Callao	Sechura Bay	Mancora, Punta Sal, Tumbes
Nudibranchia: Doridoidea	<i>Doris fontainei</i>	x				
	<i>Diaulula variolata</i>	x	x			
	<i>Baptodoris peruviana</i>	x				
	<i>Rostanga cf. pulchra</i>	x				
	<i>Corambe lucea</i>	x	x	x	x	
	<i>Okenia luna</i>			x		
	<i>Polycera priva</i>		x			
“Arminoidea”	<i>Janolus rebecca</i>		x		x	
Dendronotoidea	<i>Doto uva</i>	x		x		
	<i>Hancockia schoeferti</i>	x				
Aeolidoidea	<i>Phidiana lottini</i>	x	x	x		
	<i>Flabellina cf. cerverai</i>			x	x	
Cephalaspidea	<i>Navanax aenigmaticus</i>		x		x	x
Sacoglossa	<i>cf. Ercolania evelinae</i>	x				
	<i>Elysia cf. hedgpethi</i>		x		x	

known from Chile. Besides giving new morphological, biological and distributional data we also modify and discuss zoogeographic patterns observed for temperate southeastern Pacific nudibranchs, which were biased to information from Chile in the past.

Material and methods

In November and December 2006 we performed a public transport (bus, mototaxi, taxi) based survey of opisthobranch molluscs at 7 major stations along the Peruvian coast at San Juan de Marcona (several sites), Ica; Reserva Nacional de Paracas (Laguna Grande, Islas Ballestas, and 3 sites near Paracas), Ica; La Punta, Callao; Bahía Sechura (several sites), Piura; Máncora (several sites), Piura; Punta Sal (several sites), Tumbes; Puerto Pizarro, Tumbes (see station list below; Fig. 1). All stations were intertidal and shallow subtidal (collecting via tide pooling and snorkelling), and all but Callao and Puerto Pizarro also were subtidal down to 15–27 m depth, with SCUBA dives at several sites. We investigated all available benthic habitats, such as soft and rocky bottoms, deeper rock walls, caverns, and macroalgae; gravel, algae, hydrozoa and other substrate samples were collected and searched for small opisthobranchs in aquaria and under the binocular microscope. Specimens, egg masses and potential prey were collected, members of each species documented in living condition, and specimens fixed (4 % formalin-seawater; 3.7 % buffered glutaraldehyde, 70 % or 96 % ethanol) for further taxonomic analysis. Specimens were identified externally to the level possible using the keys and descriptions given by Schrödl (2003, 2009) and more specialized literature referred to separately.

Reference specimens were deposited at the Zoologische Staatssammlung München (ZSM) and the Colección de Zoología Acuática (CZA) of the Universidad Peruana Cayetano Heredia. Additional specimens from other collecting trips along the Peruvian coast (Paracas, Pucusana, Bahía Ferrol, Máncora and Punta Sal) and photographs of living specimens were provided by one of the authors (YH).

Collecting sites

- 1) **San Juan de Marcona**, Ica, southern Peru. A) Rocky reefs (15°22'11" S, 75°12'16" W) off Punta de San Juan de Marcona, rocky bottom, at 6–15 m depth, water temperature 15 °C, strong currents from swells, 24.11.2006. B) Punta San Juan de Marcona (15°21' 23" S, 75°10'44" W), sandy beach with rocks, at 0–2 m depth, water temperature 15 °C, 22.11.2006. C) Fishery harbour, pier (15°21'29" S, 75°09'42" W) with macroalgae and epizoans, 25.11.2006.
- 2) **Reserva Nacional de Paracas**, Ica, southern Peru. A) Sediment and hard bottoms around Laguna Grande (14°09' S, 76°15' W), at 0–8 m depth, water

temperature 23 °C, 27.11.2006. B) Islas Ballestas (13°43.8' S, 76°23.9' W), steep rock walls, at 8–15 m depth, currents and swell, water temperature 15 °C, 28.11.2006. C) Peninsula, sediment bottom off sandy beach, at 3–5 m depth, 28.11.2006. D) Paracas, scallop farm on sediment bottoms (13°48.7' S, 76°17.6' W), at 0–5 m depth, 28.11.2006. E) Paracas, fishery pier (15°21'20" S, 75°09'39" W), shallow water macroalgae and epizoans, 25.11.2006.

- 3) **La Punta**, Callao, central Peru. Sandy bottom with stones, and pier of IMARPE (12°04'04" S, 77°09'38" W) with macroalgae and epizoans, at 0–3 m depth, water temperature 18 °C, 22.11.2006.
- 4) **Bahía Sechura**, Piura, northern Peru. A) Several collecting stations off Bayovar (5°48' S, 81°02' W), rocky and sandy bottoms at 4–27 m depth, 8.12.2011. B) Sediment bottom with scallop farms (5°46' S, 80°58' W), at 6–10 m depth, 09.12.2006.
- 5) **Máncora**, Piura, northern Peru. A) Fishery pier (4°6'36" S, 81°42' W) with macroalgae and epizoans, at 0–5 m depth, 02.12.2006 and 06.12.2006. B) Sandy beach with intertidal and shallow subtidal rocks and stones (4°06'20" S, 81°03'31" W), 02.12.2006 and 04.12.2006.
- 6) **Punta Sal**, Tumbes, northern Peru. A) Several collecting stations off coast (3°59' S, 80°59' W), rocky and sandy bottoms, at 8–15 m depth, 03.12.2006. B) Pier of Cancas (3°56' S, 80°56' W), 05.12.2006.
- 7) **Puerto Pizarro**, Tumbes, northern Peru. Isla de Amor (3°29'47" S, 80°23'28" W), intertidal sands and mangroves, 01.12.2006.

Results

Euthyneura, *Nudipleura*, *Nudibranchia*,
Doridoidea, "*Cryptobranchia*", *Dorididae*,
Doris Linnaeus, 1758

Doris fontainei (D'Orbigny, 1837)

Fig. 2

Material. Many specimens with egg masses, 6 specimens collected (ZSM Moll 20090686), rocky reefs off Punta de San Juan de Marcona, 24 November 2006, at 8–15 m depth. Two specimens (ZSM Moll 20100765) from Pucusana, south of Lima, 30 August 2004, coll. YH. An additional record comes from an islet in the Bahía Ferrol (9°08'59.58" S, 78°36'48.75" W, Ancash, at 17 m depth, 12 °C water temperature, found on 25 September 2007 during the ESPER 2007 Expedition (Proyecto Esponjas del Peru, YH).

Distribution. Bahía Ferrol, Ancash, Peru (9°S; Uribe et al. 2013) and south along the Peruvian and entire Chilean continental coast, as well as Argentinian Patagonia to northern Argentina (see Schrödl 2003, 2009, Schrödl et al. 2005).

Observations. As usual for central and northern Chilean specimens (Schrödl 2009), living specimens from Peru show a network of dark pigment between the notal tubercles. Egg masses are broad translucent ribbons with up to 6 spirals, containing small yellow eggs.

Remarks. This species was revised in detail under the name *Anisodoris fontaini* by Schrödl (1997a, 2000a), then called *Doris fontaini* by Valdés & Muniain (2002), and placed tentatively into the genus *Archidoris* by Schrödl (2003). We feel that comprehensive molecular phylogenetic analyses are required to rearrange dorid systematics. Regardless of uncertain generic affiliations and different opinions on the valid species name, this southern American species is unmistakable because of its large body size up to 10 cm, triangular, grooved oral tentacles and large notal tubercles. For a temperate benthic invertebrate species it has an extreme latitudinal range of roughly 45 degrees in the Pacific, and still 20 latitudinal degrees in the southwestern Atlantic.

Discodorididae, *Diaulula* Bergh, 1878

Diaulula variolata (D'Orbigny, 1837)

Fig. 3

Material. Several specimens, 8 collected (ZSM Moll 20090679, 20100787), at and off Punta de San Juan de Marcona, 23–24 November 2006, at 2–15 m depth. Two specimens (ZSM Moll 20100760) from Paracas, 3 October 2004, coll. YH; two specimens (ZSM Moll 20100819), 26 November 2006.

Distribution. Paracas, Peru (~14°S; Uribe et al. 2013) and south along the Peruvian and Chilean continental coast to Concepción (see Schrödl 1997b, 2003). More recently, *D. variolata* was found off Playa Caballito (41°14'48"S, 73°51'45"W; ZSM Moll-20110395) at 2 m depth, (new range extension herein) and even reported from the southern part (51°S) of the Chilean fjord region by Aldea et al. (2011); the latter record, however, needs confirmation (Uribe et al. 2013).

Observations. Light microscopic and SEM analyses herein show that typical caryophyllidiid tubercles, with a crown of spicules surrounding a ciliary sensory knob, are present in *D. variolata*. While smaller tubercles are slender caryophyllidiids, larger tubercles apically show a more complex pattern of spicules and sensory ciliary fields.

Remarks. *Doris variolata* D'Orbigny, 1837 was transferred to *Anisodoris* by Bergh (1898). According to Valdés & Gosliner (2001), the latter genus is

in synonymy with the senior *Diaulula*; thus Schrödl (2003) briefly discussed this species under *Diaulula variolata*. While members of *Diaulula* are supposed to have special caryophyllidiid tubercles, Valdés & Muniain (2002) could not find caryophyllidiid tubercles as earlier described from *D. variolata* by Marcus (1959) in their material available, and thus transferred the species to the caryophyllidiid-lacking genus *Peltodoris*. However, having caryophyllidiid (small) tubercles, a generic placement of *D. variolata* within *Diaulula* may be justified until comprehensive genetic data is available on dorid nudibranchs confirming or rejecting current morphology-based classification.

Baptodoris Bergh, 1884

Baptodoris? peruviana (D'Orbigny, 1837)

Fig. 4

Material. Three specimens (ZSM Moll 20100802), off Punta de San Juan de Marcona, 24 November 2006, at 6–12 m depth. Additional specimens were collected by Vreni Häussermann and Günther Försterra in Chile, during December 1997: one specimen (ZSM Moll 20110443), Playa Corazones (18°31'39"S, 70°19'18"W), Arica, at 4–5 m depth; one specimen (ZSM Moll 20110460), west of Punta Lobos (20°59'56"S, 70°09'49"W), Rio Seco, at 15 m depth; two specimens (ZSM Moll 20110465), Playa Piquero (26°08'S, 70°40'W), Pan de Azucar, at 8 m depth.

Distribution. San Lorenzo (off Callao), Peru to Los Molles, Chile (Schrödl 2003, Fischer & Cervera 2005a). Early records from Galápagos and Valparaíso need confirmation (see Schrödl 2003).

Remarks. The synonymy of the just externally known *Doris peruviana* D'Orbigny, 1837 from Callao with the Chilean *Platydoris punctatella* Bergh, 1898 was proposed by Schrödl (2003) based on characteristic external shape and whitish or yellowish coloration with the notum scattered with dark dots, except for the margin. This synonymy was confirmed by Fischer & Cervera (2005a), who designated a neotype for *Doris peruviana* using a specimen from Iquique, northern Chile. The latter authors mentioned a museum label of one specimen saying that it was uniformly orange coloured in live. We cannot confirm this assumed intraspecific colour variability, since all newly collected Chilean and Peruvian specimens resemble the originally described colour pattern.

Dorgan et al. (2002) stated that *Platydoris punctatella* ("from Peru") due to external shape does not belong to the genus *Platydoris*, and thus they did not include it into their phylogenetic analysis. Schrödl

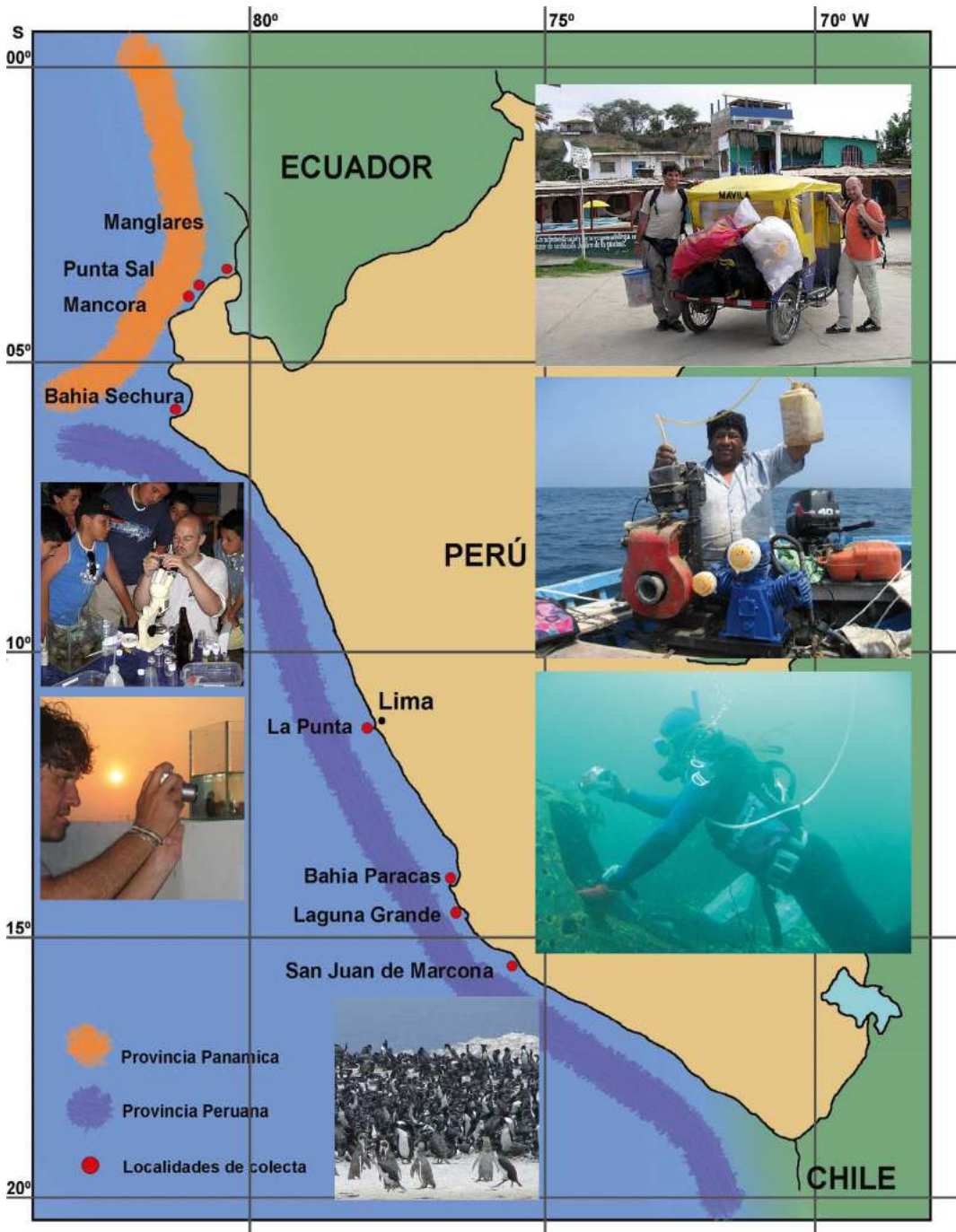


Fig. 1. Map of collecting areas. Large inserts show authors and equipment transported via mototaxi in Mancora, fisherman operating hookah diving compressor, and second author collecting in cold waters off San Juan de Marcona using compressor and garden hose. Small inserts show authors documenting live specimens after collecting, and Humboldt penguins resting at the Atacama desert coast, southern Peru.

(2003) interpreted the cool water species *P. punctatella* as a potential stem offshoot of *Platydorid*, still lacking the characteristic, very flattened shape and wide free mantle rim of mainly tropical congeners. Fischer & Cervera (2005a) found denticles on all radular teeth of *Platydorid peruviana* and considered this as an apomorphy of the genus *Baptodorid*. However, members of *Baptodorid* (as listed in their table 1) are heterogeneous regarding other anatomical features, e.g. regarding the absence versus presence of large vaginal and/or atrial hooks, and thus the monophyly of such assembly may be doubted. As mentioned by Fischer & Cervera (2005a), shapes of radula teeth also differ within *Baptodorid*, and radular denticles are present on outer radular teeth also in some *Platydorid* species. Overall, members of the probably closely related genera *Baptodorid* and *Platydorid*, both sister to *Gargamella* (see Garovoy et al. 1999), show a mixture of radular and inconsistently defined and coded reproductive features (see Garovoy et al. 1999, Dorgan et al. 2002, Fischer & Cervera 2005a) that indicates considerable convergence and unclear basal relationships. Although listing this species in the genus *Baptodorid* (see Uribe et al. 2013) for practical reasons, we still emphasize that molecular markers are needed to clarify the phylogeny of such problematic caryophyllidiid-bearing dorids.

Rostanga Bergh, 1879

Rostanga cf. *pulchra* MacFarland, 1905

Fig. 5

Material. One specimen (ZSM Moll 20100459), off Punta de San Juan de Marcona, 24 November 2006, at 6–12 m depth.

Distribution. *Rostanga pulchra*, if a single species, would occur in temperate waters of South America and north-eastern Pacific (Schrödl & Grau 2006, Alvim & Pimenta 2013). Earlier reports of *R. pulchra* from Peru were based on range extrapolations (see Uribe et al. 2013). So this is the first record of *Rostanga* from Peru that is substantiated by material collected.

Remarks. Preliminary molecular data indicates that northern and southern hemispherical *Rostanga pulchra* may belong to different species (unpublished data); the identity of the Peruvian specimens remains to be investigated.

“Phanerobranchia”, Onchidorididae s.l., *Corambe* Bergh, 1869

Corambe lucea Marcus, 1959

Fig. 6

Material. Many specimens with egg masses, 13 specimens collected (ZSM Moll 20080512–16, 20100458, 20100462), pier of San Juan de Marcona, 25 November 2006, at 0–3 m depth, on *Macrocystis*. Many specimens with egg masses, 1 specimen collected (ZSM Moll 20080523), Ballestas Islands, 28 November 2006, at 8–15 m depth, on red algae with *Membranipora*. Many specimens, 15 specimens collected (ZSM Moll 20090491–92, 20090663), pier of IMARPE, Punta de Callao, 22 November 2006, at 0–3 m depth. Many specimens, 6 specimens collected (ZSM Moll 20090743, 20090747, 20090767), sandy bottom (05°47' S, 81°03' W) off Bayóvar, Bay of Sechura, northern Peru, 8 December 2006, at 27 m depth, on *Caulerpa* and red algae.

Distribution. Sechura Bay, northern Peru, along the Peruvian and Chilean coast south to Golfo Corcovado (almost 44° S), southern Chile (see Schrödl 2009). These are the first records of *C. lucea* from Peru, extending its known range by approx. 18 latitudinal degrees to the north.

Observations. Among specimens showing the normal mottled, cryptic coloration (Fig. 6), in Sechura Bay we found a single albinistic specimen lacking any body pigmentation. Albinism in otherwise pigmented opisthobranch species is rarely encountered (see Marcus 1975, Roginskaya 1990).

Remarks. *Corambe lucea* was known from intertidal and shallow subtidal waters, and was usually associated with *Macrocystis pyrifera* covered with colonies of its prey, the bryozoan *Membranipora isabelleana* (see Schrödl & Wägele 2001, Schrödl et al. 2005). The present record from relatively deep sandy bottoms off Sechura Bay with nests of green and red algae, the latter covered with *Membranipora* colonies, suggests that *C. lucea* has a wider ecological and bathymetrical range.

The anatomy and phylogeny of Peruvian and worldwide Corambidae were addressed in recent works (Martynov & Schrödl 2011, Martynov et al. 2011) showing that corambids are an anatomically derived part of the family Onchidorididae, with evolutionary adaptations to new habitats and shorter life cycles driven by heterochronic shifts in development.

Okenia Menke, 1830

Okenia luna Millen, Schrödl, Vargas
& Indacochea, 1994
Fig. 7

Material. Many specimens, 6 specimens collected (ZSM Moll 20090669, 20090675), pier of IMARPE, Punta de Callao, 22 November 2006, at 0–3 m depth, on algae and epibionts.

Distribution. Ancón, Peru to Bahía de Coliumo, central Chile (Schrödl 2003).

Observations. No endoparasitic splanchnotrophid copepods were found in the herein investigated specimens, but *Ismaila androphila* Haumayr & Schrödl, 2003 is often associated to Chilean populations of *O. luna* (see Haumayr & Schrödl 2003, Schrödl 2003).

Polyceridae, *Polycera* Cuvier, 1817

Polycera priva Marcus, 1959
Fig. 8

Material. Two specimens were photographed at Islas Ballestas (13°43'46"S, 76°23'18.33"W) at a depth of approx. 15 m, by YH on 13 August 2002.

Distribution. Paracas, Peru (herein), and Chilean Patagonia (see Schrödl et al. 2005, Schrödl 2009). This is the first record of *P. priva* from Peru and the Peruvian faunal province. The geographical range of *P. priva* was previously thought to be very narrow, i. e. limited to the northern part of the Chilean fjord region (41–44°S), but is herein extended by almost 30 latitudinal degrees to the north.

Observations. Apart from a single occasion, to our knowledge *Polycera priva* has never again been found in Paracas or in Peru since.

Remarks. *Polycera priva* was redescribed in anatomical detail by Schrödl et al. (2005). Because of sharing the characteristic body shape and coloration, there is little doubt that our Peruvian photographic record refers to *P. priva*. Future studies will explore whether this species is a regularly overlooked Peruvian species extending south to the southern Chilean fjords, or basically Magellanic, as numerous recent findings in fjords and channels had indicated (Schrödl 2009), with just sporadic occurrences in far northern but still Humboldt current influenced areas. The latter scenario could be explained by northwards transport of larvae with currents, plus triggered metamorphosis in the presence of adequate adult prey.

“Arminoidea”, Zephyrinidae, *Janolus* Bergh, 1884

Janolus rebecca Schrödl, 1996
Fig. 9

Material. One specimen (ZSM Moll 20080529) collected at Paracas, Industrial harbour, southern Peru, 28 November 2006, at 2–5 m depth, on epibionts on nets of scallop aquacultures; three specimens (ZSM Moll 20100761) collected at Paracas, 3 October 2004, by YH. Six specimens (ZSM Moll 20090726, 20090727), collected from nets of scallop aquacultures off Bayóvar, Bay of Sechura, northern Peru, 09 December 2006, at 6–10 m depth.

Distribution. Bay of Sechura, northern Peru (first record for Peru), to Bahía Inglesa, northern Chile (Schrödl 2003).

Remarks. Specimens found in Peru externally agree with descriptions of northern Chilean *J. rebecca* by Schrödl (1996b, 2003). Digestive gland branches are brownish, ramified within the cerata and visible through the integument, contrasting *J. rebecca* from the formal description of *J. chilensis* Fischer, Cervera & Ortea, 1997 by Fischer et al. (1997). Most of the Peruvian specimens were associated with nets of scallop aquacultures, obviously feeding on epibiontic bryozoans. We cannot rule out the possibility of artificial introduction of *J. rebecca* via aquaculture activities. More likely, however, we just sampled additional populations from a natural, continuous geographic range from northern Chile to northern Peru.

Dendronotoidea, Dotidae, *Doto* Oken, 1815

Doto uva Marcus, 1955
Fig. 10

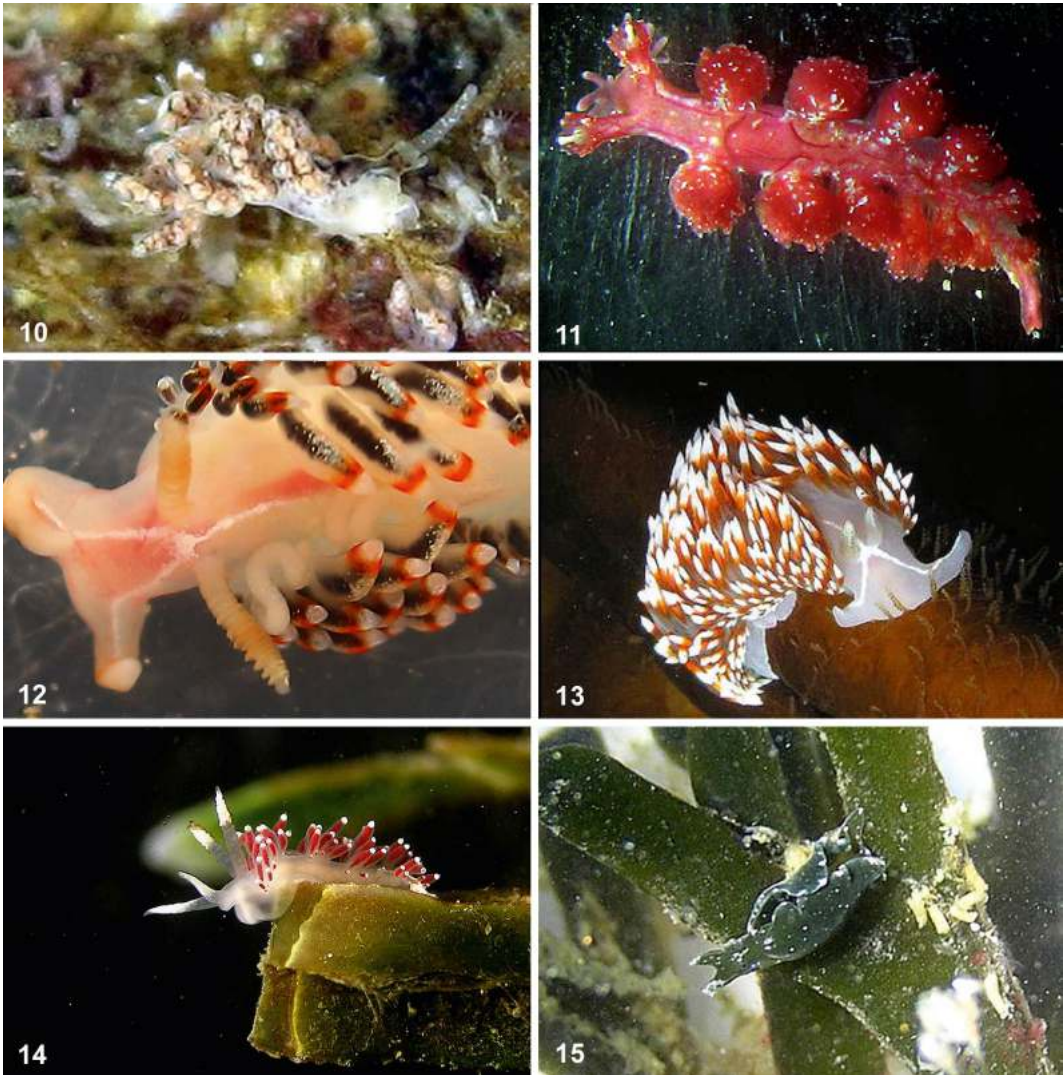
Material. Three specimens collected (ZSM Moll 20100455, 20100461), off Punta and pier of San Juan de Marcona, Ica, southern Peru, 23 and 25 November 2006, at 0–4 m depth. Many specimens, 2 specimens and oviposture collected (ZSM Moll 20080524, 20080525, 20020100839), Ballestas Islands (13°43'53"S, 76°23'59"W), off Paracas, Ica, southern Peru, 28 November 2006, at 8–15 m depth, on algae with hydrozoans. Many specimens, 51 specimens collected (ZSM Moll 20000665, 20090674), pier of IMARPE, Punta de Callao, 22 November 2006, at 0–3 m depth, on algae.

Distribution. Callao, Peru (herein), to southern Chilean fjord region (48°S); southern Brazil (see Fischer et al. 2006).

Remarks. Fischer et al. (2006) redescribed Chilean and Brazilian specimens of *Doto uva* in morphologi-



Figs 2–9. Peruvian sea slug species, living specimens. **2.** *Doris fontainei* (ca 5 cm), San Juan de Marcona. **3.** *Diaulula variolata* (ca 5 cm), San Juan de Marcona. **4.** *Baptodoris peruviana* (ca 3 cm), San Juan de Marcona. **5.** *Rostanga* cf. *pulchra* (ca 1 cm), San Juan de Marcona. **6.** *Corambe lucea* (ca 1 cm), Callao. **7.** *Okenia luna* (ca 1 cm), with egg masses, Callao. **8.** *Polycera priva* (ca 2.5 cm), Paracas. **9.** *Janolus rebecca* (ca 2 cm), Paracas.



Figs 10–15. Peruvian sea slug species, living specimens. **10.** *Doto* cf. *uva* (ca 5 mm), Callao. **11.** *Hancockia schoeferti* (ca 1.5 cm), San Juan de Marcona. **12.** *Phidiana lottini* (ca 2 cm), infested with splanchnotrophid endoparasites, 2 pairs of egg-sacs protruding from body; San Juan de Marcona. **13.** *Phidiana lottini* (ca 3 cm), non-infested; Paracas. **14.** *Flabellina* cf. *erverai* (ca 7 mm), Sechura Bay. **15.** *Elysia* cf. *hedgpethi* (ca 5 mm), Paracas.

cal and histological detail; these authors suspected that a complex of cryptic species may explain the considerable external and colour variation observed. Our specimens from San Juan de Marcona resemble Chilean specimens by having quite stout cerata, while specimens from Paracas and Callao may

have more elongated ones. Comparative molecular studies are required to resolve the status of this apparently widespread species, under current concepts showing a disjunct amphi-South American range (Schrödl 2003).

Hancockiidae, *Hancockia* Gosse, 1877

Hancockia schoeferti Schrödl, 1999

Fig. 11

Material. Eight specimens collected (ZSM Moll 20100460, 20100463), pier of San Juan de Marcona, Ica, southern Peru, 25 November 2006, at 0–3 m depth, on algae with hydrozoans.

Distribution. San Juan de Marcona, Peru (first record from Peru), and central to southern Chile (37–43°S) (Schrödl 2009).

Remarks. *Hancockia schoeferti* is an opportunistic species, in central and southern Chile occurring in locally high abundances on seasonally hydrozoan covered algae such as kelp (Schrödl 1999a). Our finding in hydrographically similar, rather cold Peruvian waters suggests it will ultimately be found in localities in between as well.

Aeolidioidea, Glaucidae, *Phidiana* Gray, 1850

Phidiana lottini (Lesson, 1831)

Figs 12, 13

Material. Many specimens with egg masses, 1 specimen collected (ZSM Moll 20100457), rocky reefs off Punta de San Juan de Marcona, 24 November 2006, at 8–15 m depth. Several specimens, pier of San Juan de Marcona, Ica, southern Peru, 23 and 25 November 2006. Many specimens, 2 specimens collected (ZSM Moll 20100762), off Paracas (13°48'50"S, 76°17'36"W), 28 November 2006, at 2–4 m depth, on algae, nets and buoys. One specimen (ZSM Moll 20100728) collected at Pucusana, south of Lima, Peru, 19 July 2005, by YH. Several specimens, 2 specimens collected (ZSM Moll 20090670), pier of IMARPE, Punta de Callao, 22 November 2006, at 0–3 m depth, on algae.

Distribution. Callao, central Peru, to Melinka, Guaitecas Islands (44°S), northern part of the Chilean fjord region.

Observations. One specimen collected off San Juan de Marcona is infested by at least two female *Ismaila* (Copepoda: Poecilostomatoida: Splanchnotrophidae), possibly *I. robusta* Haumayr & Schrödl, 2003. These highly specialized endoparasites (see Anton & Schrödl 2013a,b) hide their externally protruding paired egg sacs between the cerata of the host (Fig. 12). While central Chile hosts an especially rich splanchnotrophid fauna (Schrödl 2002, Haumayr & Schrödl 2003), apparently representing a rather recent radiation switching towards different hosts (Anton & Schrödl 2013b), this is the first record of a splanchnotrophid copepod for Peru.

Remarks. The taxonomy of *Phidiana lottini* and its junior synonym *Phidiana inca* was revised by Schrödl (1996a, 2003). In the past, there were several records of *P. lottini* from Callao, and Uribe et al. (2013) reported it from Isla Santa, Ancash, and, with reservations, from tropical waters of Tumbes, which should be confirmed by future surveys.

Flabellinidae, *Flabellina* Voigt, 1834

Flabellina cf. *cerverai* Fischer, Van der Velde & Roubos, 2007

Fig. 14

Material. Many specimens with egg masses, 42 specimens collected (ZSM Moll 20090668), pier of IMARPE, Punta de Callao, 22 November 2006, at 0–3 m depth. One specimen, Sechura Bay, at 6–10 m depth, 9 December 2006.

Distribution. Bay of Coliumo, central Chile, to Sechura Bay, northern Peru (range extended herein).

Remarks. As *Flabellina* sp. 2, this species was briefly described by Schrödl (1996a, 2003) as a small slender aeolid with white-tipped, light reddish or brownish cerata in groups, wrinkled rhinophores and propodial tentacles, occurring in central Chile and in Ancón, Pucusana, Peru (found by S. Millen). The herein reported material from Peru is highly similar and thus likely to be conspecific. *Flabellina* sp. 2 externally resembles *Flabellina cerverai* Fischer, Van der Velde & Roubos, 2007 that was described based on material from Coquimbo, Chile (Fischer et al. 2007). Comparative anatomical and molecular studies may confirm conspecificity.

Euthyneura, Tectipleura, Euopisthobranchia, Cephalaspidea, Aglajidae, *Navanax* Pilsbry, 1895

Navanax aenigmaticus (Bergh, 1893)

Material. Five specimens (ZSM Moll 20100035, 20100777), Laguna Grande, on sandy bottom, at 2–8 m depth, 27.11.2006. One specimen (ZSM Moll 20100773), Sechura Bay, sediment bottom with scallop farms, at 6–10 m depth, 09.12.2006. One specimen (ZSM Moll 20100730), Punta Sal, collected by YH, 11.05.2005. Four specimens (ZSM Moll 20100753, -54), Máncora, collected by YH, 10.04.2005.

Distribution. Eastern Pacific (Ornelas-Gatdula et al. 2012), i. e. Southern California to Panama, Galapagos. Northern Peru (Uribe et al. 2013) to central Chile (see Schrödl 2007a,b).

Remarks. Recent molecular analyses have shown that eastern Pacific *N. aenigmaticus* differ from externally similar Atlantic species (Ornelas-Gatdula et al. 2012). *Navanax aenigmaticus* is common in Panamanian and warm northern Peruvian waters, and was very abundant in southern Peruvian Laguna Grande; this is an almost closed shallow lagoon showing much higher water temperatures than nearby open waters (23 °C versus 15 °C during our visit). This suggests Laguna Grande populations are either permanent or temporary relics of warm water fauna extensions during El Niño years. In Laguna Grande, *Navanax aenigmaticus* apparently preys upon *Bulla punctulata* A. Adams in Sowerby, 1850, another tropical species (see Uribe et al. 2013), which was also just locally abundant in sandy subtidal sediments.

**Euthyneura, Tectipleura, Panpulmonata,
Sacoglossa, Plakobranchea, Limapontiidae,
Ecolania Trinchese, 1872**

cf. *Ecolania evelinae* (Marcus, 1959)

Material. Single specimen (ZSM Moll resin block 9k1), pier, Paracas, on algae, 25 November 2006.

Distribution. Magellan Strait, Chile to Paracas, Peru (first record of limapontiid sacoglossans for Peru).

Remarks. The single tiny specimen externally resembled specimens collected in Chile (Schrödl 1996a). Secure generic placement requires histological examination of the reproductive system.

Plakobrancheidae, *Elysia* Risso, 1818

***Elysia* cf. *hedgpethi* Marcus, 1961
Fig. 15**

Material. Four specimens (ZSM Moll 20080519-22), pier, Paracas, on algae, 26 November 2006.

Distribution. Magellan Strait and Chilean coast to Paracas (Schrödl 2009, as *E. patagonica*) and Sechura herein; this appears to be the first record of a small-sized green *Elysia* species for Peru that is backed by collected material.

Remarks. Small, green specimens with small red and blue dots collected from temperate Peruvian waters herein externally resemble those from the Magellan Strait (Schrödl, 1996a) and from the central Chilean Bay of Coliumo (unpublished). Fischer & Cervera (2005b) reported on (preserved) *E. hedgpethi* from central Chile, and further green *Elysia* specimens were found near Coquimbo (Martin Thiel,

pers. comm.). Molecular studies are needed to test the assumed conspecificity of northeastern Pacific *E. hedgpethi* with southeastern Pacific ones, and with externally similar but larger growing southwestern Atlantic *E. patagonica*.

Discussion

There can hardly be any greater contrast in climate and geography as that between cold-humid and glacier-influenced southern Patagonian fjords and the northern Chilean and Peruvian Atacama desert coasts. Nevertheless, we found several marine euthyneuran species occurring in both areas. *Doris fontainei* (or *Archidoris fontaini*) is remarkable in showing considerable colour variation (Schrödl 2003, 2009) and having an enormous latitudinal extension, from Mar del Plata in warm-temperate northern Argentina throughout the colder Magellan region to northern (non-tropical) Peru, as found herein. Molecular studies are needed to explore the connectivity and phylogeography of Pacific and Atlantic populations. Prior to this study, *Hancockia schoeferti* was reported from Chile at 43–37°S; this area was sometimes regarded as transitional between the Magellanic and Peruvian regions, or regarded as an own central Chilean faunal entity characterized by having own endemics (e. g. Brattström & Johanssen 1983, Schrödl 2003). Similarly, *Corambe lucea* appeared to show an extended central Chilean distribution pattern (see Schrödl 2003), occurring from roughly 22° to almost 44°S. Reporting *H. schoeferti* from southern Peru and *C. lucea* even from northern (non-tropical) Peru herein shows that increasing inventory may reject these and other hypotheses of endemism. Considering the present records from the Peruvian coast north to Bay of Sechura (approx. 6°N), *C. lucea* thus covers the entire range of the Peruvian faunal province and, as several other Peruvian faunal elements, it extends a bit south into Magellanic waters. This confirms earlier suggestions (Schrödl 1999b, 2003, 2009, Schrödl et al. 2005) that, at least for opisthobranchs, Chiloé Island represented an artificial, collection effort biased rather than a strict distributional border. The next candidate potentially acting as a faunal barrier is the Peninsula Taitao (ca 46°S), separating the better explored northern part of the Chilean fjord region (Northern Patagonian Zone) from the south (Häussermann & Försterra 2009).

Even more surprising was the record of the supposedly Magellanic *Polycera priva*, a previous endemic to Patagonian fjords north of the Peninsula Taitao (Schrödl 1996a, 1999b, 2003, 2009), from Islas Ballestas in southern central Peru. Similarly, a few specimens of the common Magellanic chromodoridid

Tyrinna nobilis were found in northern Chile (Schrödl & Millen 2001) and recently in Peru (Uribe et al. 2013). Overall, increasing collecting activities have shown that Magellanic opisthobranchs do not have Chiló Island as a northern distributional border, but extend more or less far to the north with regularly established, stable populations (Schrödl 1997b, 2003). Southern South American species at least sporadically extending such far to the north as suspected for *P. priva* may be an overlooked but quite common phenomenon that deserves further study in Peru. The farther north established the greater may be the risk for populations of cool-water adapted species (and their prey) to become locally and regionally extinct latest with the next El Niño event.

Hydrographic conditions are highly similar in the entire Humboldt current system (Brattström & Johannsen 1983), and water temperatures are frequently cooled down to 14 or 17 °C along the entire coast between central Chile and northern (non-tropical) Peru due to upwellings, especially during the summer with prevailing southern winds, and north of large peninsulas, forcing the Humboldt current away from the coast. Water masses and usually pelagic nudibranch larvae transported by the Humboldt current may be responsible for short to long distance dispersal. This explains the extremes, i. e. some Magellanic species inhabiting icy waters of southern Patagonia but also occurring in Peru, at least locally and sporadically. High densities of *C. lucea* at several localities all along the Peruvian coast indicate this species has reproductive local populations. We found *H. schoeferti* in a single, but reproducing population in San Juan de Marcona, thousands of kilometres away from its northernmost previous record in central Chile, indicating sporadic long distance dispersal and opportunistic exploration of locally available resources. The larger species *Polycera priva* has been found only once in Peru thus far, but with two specimens at the same site; for hermaphrodites enough to produce local offspring. More data has to be collected in Peru to see whether or not there are continuous and stable populations. Range extensions to Peru of other species already known from the Chilean part of the Peruvian faunal region, such as *Janolus rebecca* and a Chilean morphotype of *Doto uva*, or known ranges extended northwards within Peru are easily explained by limited previous collecting efforts along the Peruvian coast. In contrast to all these Magellanic or Peruvian-Chilean faunal elements, *Nacanax aenigmaticus* appears to be a warm water adapted eastern Pacific, i. e. mainly Panamanian species (Ornelas-Gatdula et al. 2012), which, however, may have a stable population in the southern

Peruvian warm water refuge Laguna Grande. At least sporadically it spreads far south to northern and even central Chile (Schrödl 2007a), possibly with warm, southward directed coastal currents during El Niño events. In summary, South-eastern Pacific opisthobranchs appear to be more widespread and flexible than expected from limited distributional data, extending their main ranges with more or less sporadic satellite populations. This may depend on changing current regimes for larval dispersal and on suitable local environmental conditions, in particular with regard to available potential prey (sessile invertebrates in most cases).

Even more strictly, splanchnotrophid parasites of the genus *Ismaila* depend on the presence of their specific opisthobranch hosts (Haumayr & Schrödl 2003, Anton & Schrödl 2013a). Interestingly, splanchnotrophids seem to be concentrated or limited to central and southern Chilean host populations (Schrödl 2002), even in host species showing a wider Chilean-Peruvian distribution and dense Peruvian populations, such as *Okenia luna*. Herein we found the first exception, referring to a single infested *Phidiana lottini* specimen among abundant conspecifics in Callao, central Peru. On the one hand, the pelagic nauplius larva of *Ismaila* implies a certain dispersal potential necessary for initial infestation of remote populations of host species. On the other hand, such dispersive ability coupled with a short life cycle would also allow for quick and massive infestation of entire host populations in Peru, as seen in central Chile (Schrödl 2003), and for following northern host populations during range shifts induced by El Niño events. Because this is apparently not the case, i. e. massive infestations by splanchnotrophids have yet to be observed in Peru, we may suspect on other potential constraints such as physiology or special population dynamics. Even a yet unknown, potentially sessile intermediate host may be considered, limiting splanchnotrophid migration to and infestation of ephemeral host populations.

In total, herein we add 7 benthic sea slug species previously reported from Chile to the coastal marine fauna of Peru. We may have found some of the species that were previously suspected to occur in Peru, i. e. *Rostanga cf. pulchra* and *Doto uva*, but with conspecificity to their Californian and Chilean look-alikes to be confirmed or rejected by genetic markers. However, we could not yet confirm the presence of *Cadlina sparsa* (see Schrödl 2000b) in Peru, predicted by Álamo & Valdivieso (1987). In particular, the common and charismatic Chilean nudibranch *Thecacera darwini* has not been found yet in Peru. Further records augmenting the documented sea slug diversity of Peru will be published successively.

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