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Colonization of Patagonian harbours (SW Atlantic) by an invasive sea squirt

(Chordata, Ascidiacea)

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Despite the poorly studied biodiversity of the Southwestern Atlantic, several exotic species have already been detected. Here we detail the distribution and abundance of the invasive ascidian *Ascidiella aspersa* (Müller, 1776) in the SW Atlantic and review its historical records. For this purpose, we determined ascidians collected since 1914 from museum collections and inspected randomly sampled natural biota collections as well as colonization on plates deployed in situ for two years throughout six major harbours along the Patagonian Argentine coast. Museum collections revealed a sudden presence of *A. aspersa* early in the 1960's. The species is actually distributed over 10 latitudinal degrees in harbours and subtidal areas along the SW Atlantic. Altogether, results suggest that this species, an exotic for the SW Atlantic, is able to colonize new areas. Further studies are needed to assess *A. aspersa* invasion impacts on biodiversity in the study area.

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Introduction

One commonly suggested invasion pattern holds that the importance of commercial shipping as a pathway should produce a greater density and diversity of exotic organisms near port areas (Cohen et al. 2000). Ecological and evolutionary consequences of invasions are greater than were previously realized. There is now convincing evidence of incipient global extinctions, rapid and extensive geographical spread of invaders, impacts on multiple species and ecosystems, transport of pathogens and disease, undetected cryptic invasions, and rapid and extensive hybridization between invaders and native species (Grosholz 2002). Ascidians, both solitary and colonial species, are one of the taxonomic groups in focus for marine invasion, as records are currently accumulated worldwide for this group. Invasive ascidians may displace native species and affect community structure of their newly invaded habitats. Many shallow water subtidal habitats in Massachusetts, USA have recently been invaded by five non-indigenous ascidian species, which occupied as much as 80 % of the primary substratum and accounted for the majority of species richness (Agius 2007).

Distribution patterns of non-indigenous ascidians are dependent upon many biological (predation, larval behaviour) and physical factors: temperature and salinity are often the most variable factors in near shore habitats and two of the most important limiting the distribution of introduced ascidians (Dijkstra et al. 2008). Certain species of the genus *Didemnum* are emerging worldwide as especially successful invaders with broad environmental tolerances and subject to little or no predation (Lambert 2007).

The Southwestern Atlantic (Argentine Sea) is among the poorly known marine regions in terms of biodiversity (Orensanz et al. 2002). However, recent documentations on the emergence of marine invasive species in this region (Hidalgo et al. 2005; Spivak et al. 2006) have resulted in scientific interest on the impacts of biological invasions on native marine biodiversity. The general survey of recorded species introductions into the SW Atlantic compiled by Orensanz et al. (2002) revealed six ascidians whose exotic status is well documented. This represents the 19 % of the total exotic marine organisms in this area. One of the largest obstacles to understanding broader patterns of invasion is the uncertainty about which species are native and which are exotic. For less well-understood groups, such as marine and estuarine invertebrates, it is a daunting task to even determine species identity, and species lists are not adequate to delineate the native fauna. A better understanding of species identity and whether they are native is crucial for further advances in invasion studies in coastal systems (Grosholz 2002). Although the status of native or exotics is difficult to establish, in part due to the scarcity of taxonomic studies, determinations on old museum collections can help to elucidate at least some of the species standings.

The ascidian family Ascidiidae Adams, 1858, possesses two morphologically similar genera, scarcely differentiated only after the dissection of individuals. The genus *Ascidia* Linnaeus, 1767 is characterized by the presence of papillae projecting from longitudinal vessels in the branchial sac, while in the genus *Ascidiella* Roule, 1883 these structures are absent. The genus *Ascidiella* is now considered to have only three species, *A. senegalensis* Michaelsen, 1914, confined to Northwest Africa (Nishikawa & Otani 2004), while *A. scabra* (Müller 1776) and *A. aspersa* are recorded from the Northeastern Atlantic, North Sea and the Mediterranean Sea (Berrill 1950, Millar 1970, Ramos Esplá 1991, Nishikawa & Otani 2004). In this latter species longitudinal vessels always outnumber the oral tentacles. This relation is used as the main difference between *A. aspersa* and its congener *A. scabra* (Lindsay & Thompson 1930, Berrill 1950). *Ascidiella aspersa*, is considered as highly invasive; although Kott (1985) considered the isolated southern populations from Australia as native, this species has been reported as invasive, spreading into the Northwestern Atlantic (Agius 2007, Altman & Whitlatch 2007, Carman et al. 2007), Australia (Cohen et al. 2000), New Zealand and India (Nishikawa & Otani 2004). Although the species was not recorded in the SW Atlantic (Van Name 1945, Diehl 1977), Monniot (1970) reported four individuals of *Ascidiella* collected during the Calypso Expedition in the Nuevo Gulf. The poor state of preservation did not allow him to determine these individuals to a specific level. Recent sampling revealed the sudden apparition of *Ascidiella aspersa* along Argentinean intertidal and subtidal coast in San Matías Gulf (Antacli et al. 2003, Lagger et al. 2006), San José Gulf (Loto 2006), Comodoro Rivadavia harbour (Rico et al. 2006) and the subtidal of Buenos Aires Province (Varela 2007).

The aim of this study is to clarify the status, distribution and abundance of the presumably exotic ascidian *Ascidiella aspersa* in the SW Atlantic, principally in the harbour areas, by determinations of museum collections and field samples. Potential dispersion processes and possible effects on benthic communities are also discussed.

Material and methods

Undetermined ascidians from the SW Atlantic deposited in two Argentinean museums, were examined during July and August 2005 in order to determine the presence of *Ascidiella aspersa* in preserved samples:

1. Museo Argentino de Ciencias Naturales Bernardino Rivadavia, Buenos Aires (MACN): 22 flasks corresponding to 14 localities from 36° to 54° S latitude, from the intertidal down to 90 m depth. Collection dates: 1914 to 2005.
2. Museo de Ciencias Naturales de La Plata (MCN-LP): 26 flasks corresponding to 14 localities from Buenos Aires Province to 55° S (Beagle Channel), subtidal from 4 to 40 m depth. Collection dates: 1916 to 2002. Identification of ascidians was accomplished using a dissecting microscope (40 ×) after dissection and staining of the preserved animals (Monniot & Monniot 1972).

Several field trips were conducted between April and October 2005 along an extended coastline (~1,500 km; from 40°48' to 54°49' S latitude), in six major but unexplored Patagonian Argentine harbours. The harbours studied were: San Antonio Este (SAE), Puerto Madryn (PM), Puerto Deseado (PD), Puerto Santa Cruz, Punta Quilla (PQ), Río Gallegos, Muelle El Turbio (ET) and Ushuaia (U) (Table 1). Three subtidal fouling samples (30 × 30 cm) were randomly collected by scratching and by SCUBA from the pilings in each of the studied harbours in order to identify the richness of introduced ascidian species, specifically of *Ascidiella aspersa*. Samples were preserved in formaldehyde (2.5 % in seawater) in the field. At the same time, 15 plates (each 20 × 20 cm) were deployed in each harbour in the subtidal zone at

2-3 m depth during low tide, in order to quantify the abundance of *A. aspersa*. Plates were left submerged for approximately two years. Once the plates were collected, they were transported on ice to the laboratory and then, settled organisms were separated from the plates and preserved in formaldehyde (2.5 % in seawater; Monniot & Monniot 1972). Identifications of the individuals were performed in the laboratory of the National University of Córdoba. For every plate, the individuals of *A. aspersa* were counted for abundance estimations. Measurements of the maximum length of individuals were made with a caliper. Data on salinity at sea surface were obtained at the sample sites when plates were deployed and then collected, while temperature was obtained by different databases (Servicio de Hidrografía Naval: www.hidro.gov.ar; Storero 2007). The individuals of *A. aspersa* collected on the plates were deposited in the Museo de Zoología, Universidad Nacional de Córdoba, Argentina.

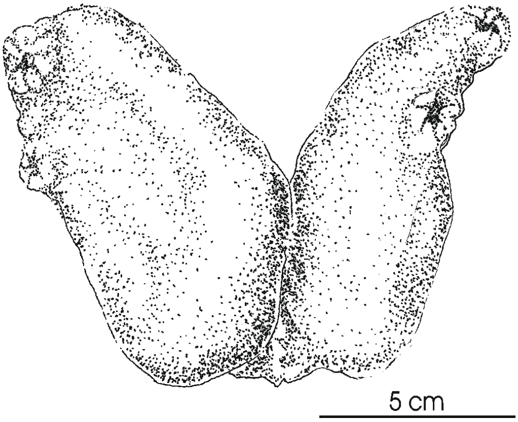

Fig. 1. *Ascidiella aspersa*. External appearance, two individuals.

Results

General description of the examined museum and field *Ascidiella aspersa* individuals:

External appearance: elliptical shape, flattened dorsoventrally (Fig. 1). Individuals attached by their ventral side. Some individuals show more or less developed stalk-like structure. Total body lengths range 2 to 13.3 cm (considering the stalk) and 1.5 to 5 cm in width. Tunic is firm, with small projections or papillae and usually fouled by organisms, as macro-algae or bryozoans attached. Colour from nearly transparent to ivory or greyish. Oral aperture is short, conical and terminal, eight-lobed; atrial aperture is situated about one-third of the body length and six-lobed.

Internal structure: mantle musculature more developed at the right side. Oral tentacles 16 to 31 in number. Dorsal tubercle C-shaped, both horns rolled inwards, aperture situated anteriorly. Dorsal lamina continuous, smooth edged, ribbed on both sides. Branchial sac with up to nine straight stigmata on each row, 31-42 and 34-56 longitudinal vessels in the left and right side, respectively. No secondary papillae are present. Digestive tract with a short esophagus, a folded stomach and intestine located at the lower half part of the left side, covered by ovary and test follicles. The anal border is smooth.

No morphological differences were observed between museum and field individuals.

Table 1. Location, surface sea water temperature and salinity of the different sampling (harbour) sites.

Harbour	Geographic position	Location	Deployment date	Recollection date	Water temperature (annual mean ± SD, °C)	Salinity (mean, psu)
San Antonio Este (SAE)	40°48'S 64°63'W	San Matías Gulf, Rio Negro	10-Oct-2005	21-April-2007	15.9 ± 6	35.7
Puerto Madryn (PM)	42°46'S 65°02'W	Nuevo Gulf, Chubut	11-Nov-2005	15-Jun-2007	13.4 ± 2.8	33.8
Puerto Deseado (PD)	47°45'S 65°55'W	Mouth of Deseado River, Santa Cruz	18-Oct-2005	22-May-2007	9.3 ± 3.3	32.7
Puerto Santa Cruz, Punta Quilla (PQ)	50°07'S 68°24'W	Mouth of Santa Cruz River, Santa Cruz	19-Oct-2005	24-Oct-2007	no data	23
Rio Gallegos, Muelle El Turbio (ET)	51°36'S 69°01'W	Mouth of Gallegos River, Santa Cruz	20-Oct-2005	23-Oct-2007	7.6 ± 4	30.7
Ushuaia (U)	54°49'S 68°18'W	Beagle Channel, Tierra del Fuego	19-Sept-2005	10-Sept-2007	7 ± 1.9	29

Museum material. The examination of the museums collections resulted in the identification of *Ascidiella aspersa* in the following material:

MACN: Label: 26404, Puerto Madryn, 12 Feb 1962 (2 individuals). Label: 26414, Puerto Madryn (harbour), 14 Feb 1962 (3 individuals). Label: 36869 Barranca Cormoranes (Puerto Deseado), 11 Feb 2005 (1 specimen attached on the colonial ascidian *Aplidium meridianum*). Label: 36865, Barranca Cormoranes (Puerto Deseado), 11 Feb 2005 (1 specimen attached on the solitary ascidian *Paramolgula gregaria*).

MCNLP: Label: 1, Olivier and Salanouve 31 Jan 1962, Punta Pardelas (42°36' S, 64°15' W, 40 individuals). Label: 2, Olivier and Bastida 18 Jan 1962, Punta Pardelas (31 individuals). Label: 4, Olivier and Salanouve 28 Jan 1962, Punta Pardelas (8 individuals).

Field material. *Ascidiella aspersa* was found colonizing the pilings and settlement plates (Fig. 2 a, b) in SAE, PM and PD and was absent from the other sampled harbours. The highest abundance was found in PD, with maximum values of colonized plates (93 %) and density (mean 3.6 individuals per plate). Animals recruited at PD were found to be heavily covered by inorganic material owing to a high sedimentation (Fig. 2b). Maximum lengths of individuals were measured at PD (the higher reached 13.3 cm) (Table 2). Individuals were divided in four length ranges: while smallest predominated in SAE (from 0 to 3.5 cm), an increase of length was observed in PM and PD with the majority of individuals measuring between 3.6 to 7 cm in length respectively. None of the individuals collected at SAE and PM reached the higher length ranges (Fig. 3).

Discussion

This study documents a wide distribution of *Ascidiella aspersa* throughout the SW Atlantic coast, colonizing subtidal hard substrates in harbours and enclosed gulfs. Along with unpublished reports on *A. aspersa* occurrence in Argentina within the last six years (Antacli et al. 2003, Lagger et al. 2006, Loto 2006, Rico et al. 2006, Varela 2007), museum collections allowed us to confirm its presence in this region for at least 45 years. The first collection was in 1962, simultaneously in two adjacent areas, Punta Pardelas and Puerto Madryn (82 km apart) and this species was not recorded in older material. Thus, its sudden presence suggests an exotic status for the SW Atlantic. The species is able to spread and colonize wide range of new localities, being now reported in Patagonia about two decades before of its invasion to the Atlantic coast of North America, where it was recorded since mid 1980's (Altman & Whitlatch 2007). Transport by anthropogenic vectors, such as ballast water and fouling hull is considered the main dispersion route by non-indigenous ascidians (Lambert 2007). The absence of *Ascidiella aspersa* in other South American areas such as Brazil (Rodrigues et al. 1998) or Chile (Lagger et al. 2009, Sanamyan & Schories 2003, Tatián & Lagger 2010, Schwindt et al. unpublished data) suggests that the dispersion of this species along the SW Atlantic was sporadic and originated by human transport. In this study, the southern distribution of *A. aspersa* is expanded. Thus, the species is distributed along nearly ten degrees of latitude at the SW Atlantic, from Mar del Plata (38° 02') in Buenos Aires Province (Varela 2007) to Puerto Deseado (47° 45' S) in the central Patagonia (this study). The rate of range expansion for introduced coastal species tends to show patterns of large range expansions over short time periods (Grosholz 2002). Considering the time elapsed since the first collection of this species, our results suggest a moderate spreading rate by *A. aspersa* along Patagonia. Its presence was detected only in three studied harbours, stressing the idea of the discontinuous dispersion owing to episodically human transport.

Differences in physical factors that characterize the areas sampled are important to consider: sedimentation, temperature and salinity were stated to be limitative for ascidians (Robbins 1985, Mc Carty et al. 2007, Carman et al. 2007, Dijkstra et al. 2008). High suspended inorganic particles can reduce the amount of food assimilated by filter-feeding ascidians, limiting the intake of utilizable food by a process of dilution and/or reducing the efficiency of assimilation of such food (Robbins 1985). Plates at PD, PQ and ET supported higher sedimentation in comparison with the other harbours (Fig. 2 a, b), characterized by clearer waters. *A. aspersa* is able to cope with high turbidity, since its abundance was the highest at PD, where heaviest sedimentation was observed. Temperature determines seasonally programmed reproduction and growth in ascidians (Dijkstra 2008). In experimental plates deployed in Massachusetts, USA Rajbanshi and Pederson (2007) found that *A. aspersa* was one of the dominant species in the plates with average 32 % cover during the fall and winter. These authors registered mortality of individuals during winter, resulting in a high seasonal fluctuation. The absence of *A. aspersa* in the plates deployed in the southern harbours (PQ, ET and U), could reflect a bias due to the time that the plates were collected. While in the northern harbours collection was from April to June (autumn and begin to winter), collection of plates in PQ, ET and U were in September and October (winter fall) (Table 1).

Although temperature determines important processes and extreme low temperatures could produces mortality, the expansion of *A. aspersa* southward into colder waters is likely to occur, considering that the species is distributed at high latitudes and low temperatures in the North hemisphere (Hoffmann & Dolmer 2000). According to Lambert (2005) most ascidians are observed in areas experiencing salinities ≥ 25 psu. However, tolerance to salinity differs according to species. In a recent study, Dijkstra et al. (2008) found that the species *Botryllus schlosseri* is better adapted to live in more euryhaline habitats than its related species *Botrylloides violaceus,* whose heart rate and mortality was more affected by low salinity. The absence of ascidians in plates deployed at PQ should be caused by low salinity. This harbour is situated at an estuary of nearly 2,000 m in width, which comprises the open of the Chico and Santa Cruz rivers into the Atlantic Ocean. Tidal regime and the river water masses determine low salinity, as measured. Other harbours, i.e., PD and ET, also located in estuaries but where salinity is not lower than 30 psu (Table 1) appear to be not limitative places for ascidians.

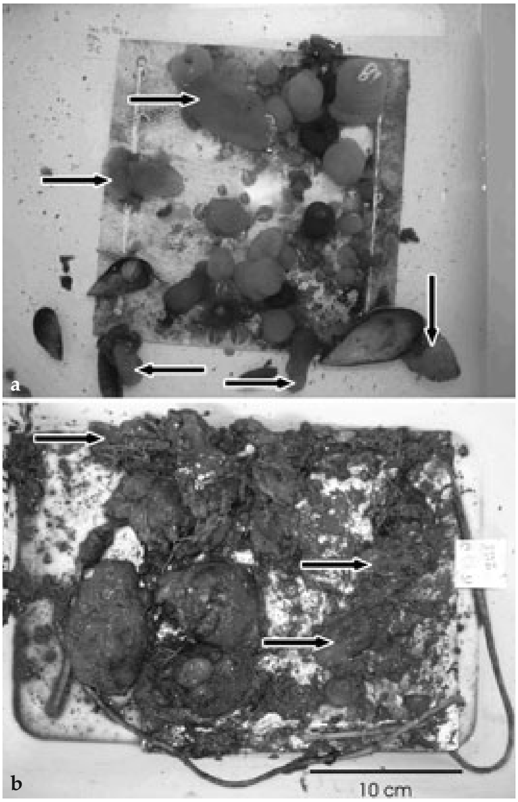

Fig. 2. Experimental plates. Black arrows indicate individuals of *Ascidiella aspersa*; **a.** Puerto Madryn (low sedimentation); **b.** Puerto Deseado (high sedimentation).

Available hard substrata in harbours, such as concrete blocks, tires, ropes or wood are easily colonized by ascidians (Whitlach & Osman 1998, Collins et al. 2002). *Ascidiella aspersa* was considered to be one of the pioneers on hard artificial substrates after three months of the deployment of these substrates (Collins et al. 2002). Similarly, Rajbanshi & Pederson (2007) noted that *A. aspersa* settled earlier than other species when plates were free from competitors. These authors found that the species had a competitive disadvantage in relation to other benthic species, i.e. the ascidian *Ciona intestinalis*, since requires more space to attach one complete side to the substrate. This competition causes fluctuation in the abundance of *A. aspersa*. Estimated densities of *A. aspersa* at PD (Table 2) are higher than those from other areas. In a North Sea fjord (Hoffmann & Dolmer 2000), density of *A. aspersa* reached up to 62 ind · m^{-2}. In Port Phillip Bay, Victoria, Australia, *A. aspersa* is one of the five most abundant fouling species with mean densities of about two ind · m^{-2} (Cohen et al. 2000), lower values than those estimated in our study sites at PD, PM and SAE. The differences found in abundance and

Table 2. Colonization, density and length of *Ascidiella aspersa* on the plates deployed at the different sampled areas.

Harbour	Number of colonized plates	Percentage of colonized plates	Number of individuals per plate (mean ±SD)	Density (individuals · m^{-2} ± SD)	Length of individuals, in cm (mean ± SD)
San Antonio Este (SAE)	4	26.7	0.4 ± 0.8	10 ± 20.7	2.7 ± 0.6
Puerto Madryn (PM)	7	46.7	1.1 ± 1.4	26.7 ± 35.9	4.1 ± 0.7
Puerto Deseado (PD)	14	93.3	3.6 ± 2.8	90 ± 69.9	6.2 ± 2.8
Puerto Santa Cruz, Punta Quilla (PQ)	0	–	–	–	–
Rio Gallegos, Muelle El Turbio (ET)	0	–	–	–	–
Ushuaia (U)	0	–	–	–	–

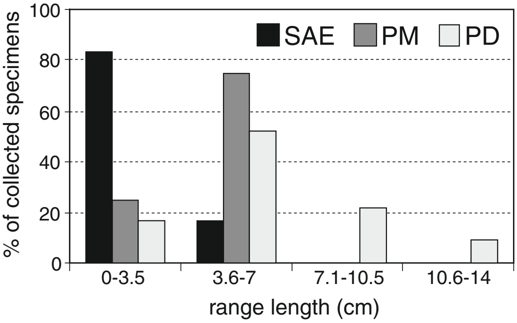

Fig. 3. Length range frequencies in individuals from SAE, PM and PD.

length range frequencies (Fig. 3) between SAE, PM and PD, reflect population dynamic (recruitment, growing, mortality). Some factors determining this dynamic, such as water temperature, availability of food or competition fluctuates with time, being particularly seasonal in cold temperate areas. More frequent observations should be taken for constructing a detailed population and community portrait, or to follow new colonized zones.

The effects produced by *A. aspersa* in the SW Atlantic coasts are not yet evaluated. Although introductions of non-indigenous species have generally resulted in adverse ecological impacts, including biodiversity decline, drop of native or commercially important species and alteration of ecosystems (Hily 1991, Altman & Whitlach 2007) other processes are also noticed. In the Bay of Brest, colonization by *Ascidiella aspersa* reduces the export of organic particles by filtration and contributes to enrich sediments by their biodeposition. This process induces the diversity of other trophic levels as deposit feeders (Hily 1991). To evaluate the effects of *A. aspersa* on the native biodiversity and prevent or diminish its negative consequences, it is important to increase the frequency of in situ studies, particularly in sensible areas such as ports, from a multidisciplinary perspective.

This work highlights the importance of museum collections for the study of marine exotic species. In addition, the finding of *Ascidiella aspersa* that was introduced more than 45 years ago indicates the necessity of performing more biodiversity studies in poorly investigated areas such as the SW Atlantic. Colonization and abundance of the species along this wide area is a basic knowledge to plan future studies that should be conducted to evaluate population dynamics and to determine the ecological effects of *A. aspersa* on the recipient communities.

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Bereits 1961 brachte die Neue Brehm-Bücherei ein kleineres Buch von Ludek Dobroruka über die Hundertfüßer heraus. Mit Spannung wurde nun die seit längerem angekündigte Neubearbeitung von Jörg Rosenberg erwartet. Um es gleich vorweg zu nehmen: Es handelt sich keineswegs um eine Neuauflage, sondern ein völlig anders konzipiertes Buch. Nicht nur der Umfang, sondern auch der Schwerpunkt hat sich stark verändert. War Dobroruka's Büchlein eine Einführung in die Welt der Hundertfüßer, so hat Rosenberg ein Grundlagenwerk geschaffen, welches eine Brücke zwischen den Handbüchern des frühen zwanzigsten Jahrhunderts und den Forschungsergebnissen der heutigen Zeit schlägt. Damit hat sich der Autor nicht nur seinen Namen unter den großen deutschen Chilopodenforschern gesichert, sondern auch ein Nachschlagewerk geschaffen, das auf einer Stufe mit "The biology of centipedes" von J. G. E Lewis steht. Ein solches Werk war dringend erforderlich, weil die Ergebnisse der deutschen Forschung in der englischsprachigen Literatur nicht immer die nötige Wertschätzung erfahren.

Geändert hat sich auch die Zielgruppe: wendet sich Dobroruka vorzugsweise an den interessierten Laien, so spricht Rosenberg die Biologen in der Forschung an. Obgleich verständlich geschrieben, dürften unerfahrene Leser von der Fülle von Spezialbegriffen und Details abgeschreckt werden. Hilfreich ist ein Glossar, welches knapp einhundert allgemeinzoologische Begriffe erklärt sowie eine Erklärung der Lagebeziehungen. Erklärungen der anatomischen Besonderheiten bei Arthropoden und speziell Chilopoden hätten das Glossar abgerundet. Besonders ausführlich und gut gelungen sind die Kapitel über den inneren Aufbau und die Feinstruktur der Hundertfüßer. Diesem Themenkomplex ist der Großteil des Buches gewidmet. Doch auch die Biologie der Tiere kommt nicht zur kurz. Diese Teile hätten allein schon ein einzigartiges Buch mit dem Titel "Feinstruktur und Biologie der Hundertfüßer" gerechtfertigt.

Aufgrund der Unterschiede in der Bearbeitung anderer Kapitel entsteht der Eindruck, dass ein sorgfältig ausgearbeitetes Buch auf Verlagswunsch erweitert wurde, um dem Anspruch einer allumfassenden Darstellung dieser Tiergruppe gerecht zu werden. Letzteres ist leider nur teilweise gelungen. So wertvoll die zusätzlichen Kapitel sind, halten sie doch mit der Qualität der anderen nicht Schritt. So ist das Kapitel über die fossilen Belege sehr knapp gehalten und geht auf Details nicht ein. Das besonders übersichtliche Kapitel "Phylogenie und Systematik" behandelt nur die Phylogenie der Ordnungen. Es ist sehr bedauernswert, dass die Systematik und die äußere Morphologie weitgehend ausgelassen wurden. Allerdings erklärt sich dies aus der Tatsache, dass keiner der Autoren ein ausgesprochener Taxonom ist. So wird bei der Nomenklatur lediglich auf die Online-Datenbank "Chilobase" verwiesen. Trotzdem wäre es gut gewesen, bei den seit über einhundert Jahren nicht mehr gebräuchlichen Gattungsnamen nicht nur *Cermatia* (heute *Scutigera*), sondern auch *Heterostoma* (heute *Ethmostigmus*) und *Branchiostoma* (heute *Rhysida*) anzupassen. Da *Branchiostoma* als Lanzettfischchen ein allbekanntes Tier der zoologischen Lehrbücher ist, kann die alte Nomenklatur zu Verwirrung führen. Auch bei den Abbildungen werden die artsystematischen Schwächen offenbar. Kann die Verwechslung der Abbildungsunterschriften bei den Farbtafeln VII und VIII noch dem Lektorat angelastet werden, so zeigt Tafel VIII (S. 24) oben nicht *Brachygeophilus truncorum* sondern *Schendyla nemorensis*, und unten keinen *Geophilus carpophagus* (die Anzahl der Beinpaare = 71 und die Färbung sprechen dagegen) sondern *Stenotaenia linearis*. Die hohe Qualität der Abbildungen wird durch die Tatsache unterstrichen, dass eine Nachbestimmung möglich ist.

Eine Definition der Familien fehlt ebenso wie eine Darstellung wichtiger Merkmalsausprägungen der äußeren Morphologie, die in der Artsystematik eine Rolle spielen. Beides fand sich noch in der knappen Abhandlung Dobroruka's und auch Lewis widmet diesem Aspekt einiges an Raum. So vermisst der Leser z. B. selbst im Register einen Verweis auf die Mandibeln. Dagegen findet er fünf Verweise auf die Mandibeldrüsen. In dem mit neun Seiten ziemlich knappen Kapitel über die äußere Morphologie werden nur die recht ähnlichen Mandibeln und Maxillen von *Scutigera* und *Lithobius* abgebildet. Mit keinem Wort wird auf die Vielgestaltigkeit der Mandibeln und Maxillen bei den Geophilomorpha eingegangen, so dass der fehlerhafte Eindruck entsteht, diese Organe seien bei den Hundertfüßern einheitlich gebaut. Hier ist die Darlegung der Morphologie bei Dobroruka, z. B. durch die vergleichende Abbildung der Kieferfüße (S. 13) bei den einzelnen Ordnungen, viel anschaulicher. Das ganze Kapitel "Äußere Morphologie" ist eher eine Fortsetzung der allgemeinen Einführung, da z. B. auch auf Aspekte der Entwicklung und Brutpflege eingegangen wird, die hier thematisch weniger passen. Es kam auch zu Diskrepanzen in der Taxonomie, weil die mitschreibenden Autoren offensichtlich unterschiedliche Ansichten präferierten. So werden die Plutoniinae auf S. 15 als Unterfamilie der Cryptopidae aufgefasst, auf S. 443 hingegen als eigene Familie Plutoniumidae aufgeführt. Die Gattung *Scolopocryptops*, Nominalgattung der Familie Scolopocryptidae (vgl. S. 15) wird auf S. 459 unter der Familie Cryptopidae geführt.

(Fortsetzung S. 138)