

XENOPHORA

T A X O N O M Y

Supplément à Xenophora, Bulletin de l'Association Française de Conchyliologie



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New insights into *Conus jourdani* da Motta, 1984 (Gastropoda, Conidae), an endemic species from Saint Helena Island

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ABSTRACT

The taxon *Conus jourdani* da Motta, 1984 from Saint Helena Island is reviewed. Originally described based upon dead, beached shells and after being virtually absent from collections, it has become available to science in live-collected state for the first time. The radular morphology has been examined. The DNA sequences of a fragment of the *cox1* gene have been obtained, and the phylogenetic relationships of this species with other cone snails from West Africa and the Mediterranean have been determined. The results indicate a relationship with the cones from Angola, confirming the placement of this species in genus *Varioconus* da Motta, 1991.

INTRODUCTION

Saint Helena Island is a small (16 x 8 km²) volcanic tropical island in the South Atlantic Ocean, and one of the most remote settled islands in the world. The nearest land is Ascension Island, which is 1,125 kilometers to the North West. The island is located 4,000 kilometers east of Rio de Janeiro, Brazil, and 1,950 kilometers west of the Kunene River, which marks the border between Namibia and Angola in Southwestern Africa (Fig. 1).

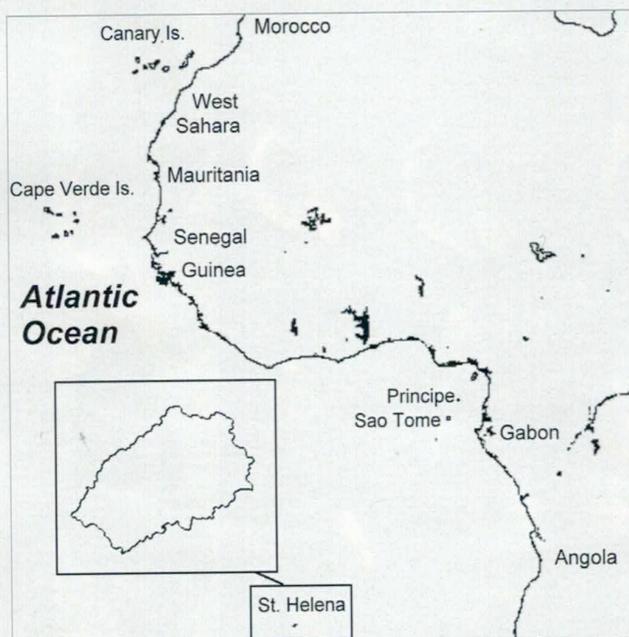


Fig. 1.- Geographic location of Saint Helena Island in the South Eastern Atlantic Ocean.

Administratively, it is part of the British Overseas Territory of Saint Helena, Ascension, and Tristan da Cunha, and it had a population 4,255 inhabitants in 2008. Apart from its isolation, the island is widely known because Napoleon Bonaparte was exiled there upon his defeat in the battle of Waterloo in 1815.

Even nowadays, Saint Helena Island remains very isolated. The reason for this is the lack of any air connections, as there is no airport and it can only be reached by sea. The main connection with Saint Helena is the *Royal Mail Ship (RMS) Saint Helena*, which runs between Saint Helena and Cape Town on a 5-day voyage, also visiting Ascension Island and Walvis Bay. The island has a commercial airport under construction expected to be open to air traffic in the summer of 2016, which will improve the communications and travels with the rest of the world.

The marine molluscs of Saint Helena were first listed in Jeffreys (1872), with a total of 41 species. A more complete annotated checklist was compiled by Smith (1890), and later updated in Smith (1892). The number of marine mollusc species and "forms" was raised to 178, but it was also stated that: "this number, however, does not at all approximate the total of species which really exist around St. Helena; for, in addition to those which I have been able to determine, there is a considerable number, nearly a hundred species, which, on account of their immature or bad condition, could not be satisfactorily identified or described." In spite of this, Smith's works were followed by a large time lapse in which no updates were introduced to the Saint Helena marine malacofauna inventory. An annotated list of the marine molluscs of Ascension Island (Rosewater 1975) compared the species from this locality with those from Saint Helena, taking the works of Smith as a reference. Thus, a total of 89 species were recorded from Ascension Island, with a low level of confirmed endemism (ca. 1%). This was compared to the much larger number of species (178) listed in Smith (1890), and also with the fact that 51% of such species were considered endemic to Saint Helena. The striking difference in the number of endemic species was attributed to the differences in the geological ages of the two Islands: Saint Helena is on the order of 20 million years old (probably dating from the Miocene), whereas Ascension Island is only 1 to 2 million years old at most (Pleistocene origin; Rosewater 1975). The rest of the Saint Helena molluscan fauna is composed of Western Atlantic species (14%), Western African species (14%), amphi-Atlantic species (5%), in addition to a 16% of pantropical, worldwide-distributed species.

Recently, thanks to the Darwin Initiative (<http://www.darwininitiative.org.uk/>), the marine biodiversity of Saint Helena Island is being mapped in order to create a Marine Management Plan. This includes a survey of the marine invertebrates of the island, of which molluscs constitute an important part. An important outcome of this project funded by the Darwin Initiative has been the publication of the book *Marine Life of St. Helena* (Brown 2014). As a result of systematic field sampling and observation, an updated list comprising 168 species of molluscs has now been entered into the Saint Helena Marine Species Database (Brown 2013), virtually as many as those described by Smith (1890).

The presence of cone snails among the molluscan fauna of Saint Helena had already been noted by Smith (1890), who listed three species of cones, namely "*Conus testudinarius* Martini", a "*Conus* sp.", and a species identified as "*Conus irregularis* Sowerby". The specimens identified as "*Conus testudinarius* Martini" (two specimens), were shells of *Chelyconus ermineus* (Born, 1778). Smith (1890) was most likely following Hidalgo (1879) as a reference for identification, since the name-author combination *Conus testudinarius* Martini was used in that work, instead of the more correct *Conus testudinarius* Hwass in Bruguière, 1792 (= *Chelyconus ermineus* (Born, 1778)). The specimen referred to as "*Conus* sp." in Smith (1890) was represented by a single much-worn shell, shaped like *Ketyconus tinianus* (Hwass in Bruguière, 1792), but apparently thicker and more strongly striated transversely. It is unclear to what species this specimen might correspond to, as no picture accompanied the description. It might represent a beached specimen of *Sciteconus mozambicus* (Hwass in Bruguière, 1792) washed ashore. This species is one of the few cone snails with a confirmed occurrence along the coasts of Namibia (Tenorio et al. 2008). The specimens cited as "*Conus irregularis* Sowerby" (= *Africonus irregularis* (G. B. Sowerby II, 1858)) were undoubtedly misidentified, as this taxon corresponds to a species endemic to the Cape Verde Islands (Monteiro et al. 2004). Smith (1890) already noted the conchological differences between Sowerby's *Conus irregularis* and the shells from Saint Helena when he wrote: "The specimens from St. Helena are of a shorter growth than those figured by Sowerby (Thes. Conch, iii. pl. 104. figs. 418, 419); they are broader at the shoulder and more suddenly contracted anteriorly. They also are more highly painted, exhibiting a considerable amount of olive-brown longitudinal streaks, which are interrupted at their middle by the bluish-white irregular zone dotted and spotted with olive-brown. The spire is either almost uniformly dark chestnut brown, or else white, blotched with that colour. Some small specimens, about 3/4 inch long, which I believe to be the young of this species, are still more brightly coloured, being more or less copiously blotched with brown-black; and the spire is radiately lined and spotted with the same tint."

Almost 100 years later, the taxon *Conus jourdani* da Motta, 1984 (Fig. 2) was described from Saint Helena Island.

The original description of this species, based upon a few dead-collected specimens, matches in many aspects the comments made by Smith (1890) about the specimens identified by him as *Conus irregularis* Sowerby: "*Conus jourdani* sp. n. description: The shell is medium / small in size, with a conical spire formed by eight whorls; the top of the last four whorls, including the shoulder, is accentuated by a marked convexity and a sculpture of strong axial lirae. The apex is obtuse.

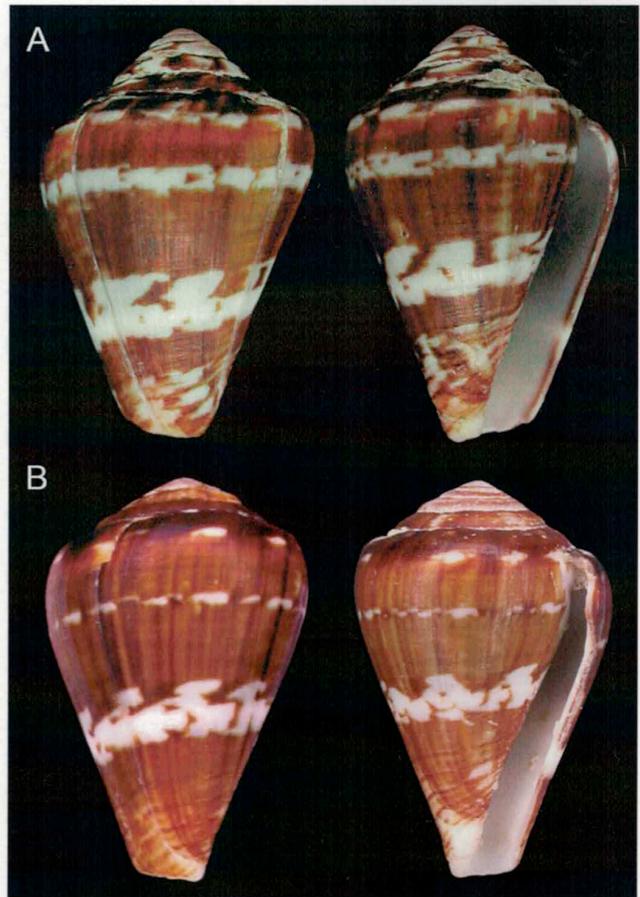


Fig. 2.- *Conus jourdani* da Motta, 1984: A) Holotype, 28.2 x 18.5 mm, MNHG 983.575; B) Paratype, 30.0 mm, SMNS collection.

The last whorl is wide at the shoulder, which is subangulated and rounded, with flat sides, falling rapidly towards the base, and with a network of fine axial and spiral striae and many transverse wrinkles at the front end. The background color is chestnut brown, orated under the shoulder with a necklace of horizontally-elongated bluish spots, followed on the periphery by a narrow band of the same color irregularly mottled with brown spots, while the lower half is uniformly bluish. The basal end has again three rows of bluish spots, similar to those in the shoulder. The aperture is bluish white inside, with an edge outside the outer lip, which is slightly sinuous and elongated toward the front end. The spire is dark brown, mottled with blue spots, while the post-embryonic whorls are bluish-brown."

The author remarked that this new species seemed to be endemic to Saint Helena Island, and that the structure and the shape of its shell was completely different from those of every other small- or mid-size cone shell found in the waters of Cape Verde, or along the western coast of Africa at the time. It was named after Ken Jourdan, a correspondent of Bob da Motta, who collected the specimens back in 1977 and brought them to the attention of the author. The considerable difficulties in getting to the windward side (south) of the island and in locating the spot where the few available specimens were collected were also narrated in da Motta (1984). Taking all evidence into consideration, it is very likely that the specimens first collected in Saint Helena and identified as "*Conus irregularis* Sowerby" by Smith (1890) were actually individuals of *Conus jourdani* da Motta, 1984.

Since its original description in 1984, no specimens of *C. jourdani* other than those in the type material (Muséum d'Histoire Naturelle, Geneva, Switzerland) and those present in da Motta's reference collection (now hosted in the Staatliches Museum für Naturkunde, Stuttgart, Germany) were available for study. The species had never been collected alive, and nothing was known about its ecology, habitat, variability, etc. Based upon shell morphology grounds, Tucker & Tenorio (2009) placed the species *jourdani* in genus *Varioconus* da Motta, 1991. Due to the very limited data on range, habitat, population status, or threats, and the fact that the species had not been recorded since its original description in the 1980s, *V. jourdani* remained assessed as "Data Deficient" in the IUCN Red List (Tenorio 2012). Survey work was recommended in order to gather sufficient data on which to determine the degree of threats confronted by this species.

Thanks to recent surveys of the marine invertebrate fauna carried out in Saint Helena Island, populations of *V. jourdani* were located and fresh specimen became available to allow a closer study of this species. Moreover, it has been possible to obtain DNA sequences and determine the phylogenetic relationships of this species with other cone snails from West Africa and the Mediterranean, to examine its radular morphology, and to gather information about its variability and distribution around the island. The results of the investigations on what can be considered a true rediscovery of a lost species are presented in this work.

MATERIAL AND METHODS

Taxonomy follows Tucker & Tenorio (2009) with the updates and modifications based on Tucker & Tenorio (2013). Most specimens were collected by SCUBA diving, in recent years. We have studied specimens from two different populations, one from the vicinity of Flagstaff Bay, to the north (10-15 m depth), and the other from Black Rock (25-35 m depth), two rocky islets located to the south end of the island. The latter locality is approximately 3 kilometers to the West of the type locality, Lot's Wife Ponds. The sampling localities are shown in Fig. 3.

Description of shell morphology follows the terminology established in Röckel et al. (1995). For morphometric comparisons, adult shells were measured with digital calipers,

with measurements rounded to the nearest 0.1 millimeter. The measurements are in a spreadsheet, deposited as supporting information at <https://dl.dropboxusercontent.com/u/30741402/jourdani.xlsx>. For comparison of shell morphometry, analysis was performed using covariance (ANCOVA) for the shell parameters: maximum diameter (MD); height of the maximum diameter (HMD); and spire height (SH), while using locality as factor, and shell length (S_L) as a covariate. Mean values of S_L were compared statistically (t -, U -, and F -tests). Statistical tests were carried out using STATGRAPHICS 5.1 or PAST3 (Hammer et al., 2001), once all the measurement sets passed the normality tests.

Terminology for radular morphology follows Tucker & Tenorio (2009), with abbreviations following Kohn et al. (1999). The number of individuals for which the entire radula was examined is indicated. Specimens of shells containing the dried animal inside were rehydrated by treatment with 70% alcohol, which was progressively diluted with water over a period of 24 hours or more, depending on size and condition of the specimen. Once the animal was soft enough, it was removed from the shell. The soft parts containing the radular sac were digested in concentrated aqueous potassium hydroxide for 24 hours. The resulting mixture was then placed in a petri dish and examined with a binocular microscope. The entire radula was removed with fine tweezers and rinsed with distilled water, then mounted on a slide using Aquatex (Merck, Germany) Mounting Medium, and examined under a compound microscope. Photographs were obtained with a charge-coupled device (CCD) camera attached to the microscope.

PHYLOGENETIC ANALYSES

Phylogenetic analyses were performed at the nucleotide level based on a data matrix that included new sequences obtained from 14 specimens representing eight cone species collected in Angola and Saint Helena Island, as well as published sequences from GenBank corresponding to cone species from the Cape Verde Islands, Senegal, and the Mediterranean Sea. Details of species, locality, GenBank accession numbers, and voucher specimens are given in Table 1. Muscle tissue was preserved in absolute ethanol, and total genomic DNA was isolated following a standard phenol-chloroform extraction protocol. Universal primers for mitochondrial *cox1* gene (Folmer et al. 1994) were used to amplify by PCR a fragment of about 600 base pairs. All PCRs were conducted in 25 μ l reactions containing 2.5 μ l of buffer (10X PCR Buffer, Mg^{2+} plus), 0.5 μ l of dNTP mixture (2.5 mM each dNTP), 0.5 μ l of each primer (10 μ M each primer), 0.2 μ l of Taq DNA polymerase (1U TaKaRa TaqTM), and 0.5 μ l of template DNA (50-100 ng/ μ l). PCR cycling conditions included an initial denaturing step at 94 $^{\circ}$ C for 5 minutes; 40-45 cycles of denaturing at 94 $^{\circ}$ C for 1 minute, annealing at 50 $^{\circ}$ C for 1 minute, and extending at 72 $^{\circ}$ C for 1 minute; and a final extending step of 72 $^{\circ}$ C for 10 minutes. PCR products were purified employing standard ethanol/sodium acetate precipitation, and directly sequenced using the corresponding PCR primers. Samples were Sanger sequenced in an automated DNA sequencer (ABI 3730xl DNA Analyzer) using the Big-Dye Deoxy Terminator version 3.1 cycle-sequencing kit (Applied Biosystems, USA) by Secugen S.L., Spain. Alignment of sequences was guided by amino acid translations (with the invertebrate genetic code) using TranslatorX (Abascal et al., 2010) and MAFFT version 5.0 (Katoh et al., 2005). Models of evolution that best fit the data set were selected independently for Bayesian in-

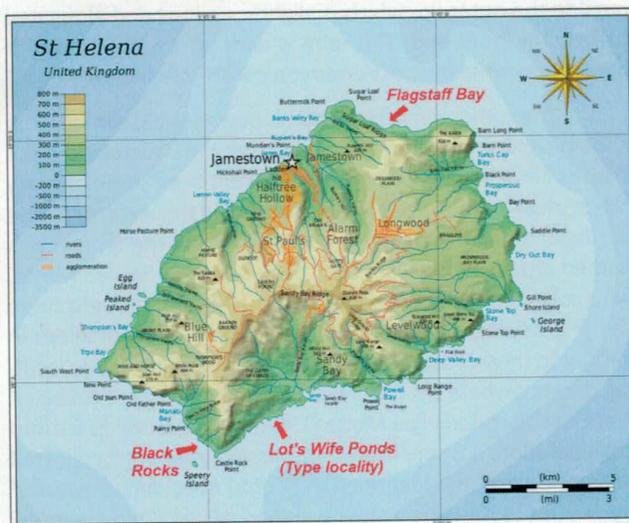


Fig. 3.- Locations of the sampling sites in Saint Helena Island (in red). Map source: Wikimedia Commons.

ference (BI) and Maximum Likelihood (ML) analyses, according to the Bayesian information criterion (HKY+G) and the Akaike information criterion (GTR+G), respectively. Both models were selected using jModelTest version 2.1.6 (Darriba et al., 2012) run on the CIPRES Science Gateway portal version 3.3 (Miller et al., 2010). BI analysis was performed with MrBayes version 3.2.6 (Ronquist et al., 2012) run on the CIPRES Science Gateway portal version 3.3 (Miller et al., 2010) conducting two independent Markov chain Monte Carlo runs (with four chains each) for 10 million generations each, sampling every 1000 generations, and discarding the first 25% of samples as burn-in. ML analysis was performed with PhyML version 3.0 (Guindon et al., 2010). The robustness of the inferred trees was tested by nonparametric bootstrapping employing 10,000 pseudoreplicates. The species from the Cape Verde Islands and *Lautoconus ventricosus* from the Mediterranean Sea were used as outgroups in both phylogenetic analyses (BI and ML).

Abbreviations

Museums and institutions

MHNG: Muséum d'Histoire Naturelle, Geneva, Switzerland.
MNCN: Museo Nacional de Ciencias Naturales, Madrid, Spain.
MNHN: Muséum Nationale d'Histoire Naturelle, Paris, France.
MSF: Molluscan Science Foundation, Inc., Owing Mills, Maryland, USA.
SMNS : Staatliches Museum für Naturkunde, Stuttgart, Germany.
UMMZ: University of Michigan Museum of Zoology, Ann Arbor, Michigan, USA.
MJT: Manuel J. Tenorio reference collection, Jerez, Spain.

Shell morphometry

S_L maximum shell length AH aperture height
MD maximum diameter RD relative diameter (= MD/AH)
SH spire height RSH relative spire height (= SH/SL)
HMD height of maximum diameter PMD relative position of the maximum diameter (= PMD/AH)

Radular morphometry

S_L/T_L shell length/radular tooth length
 T_L/AP_L radular tooth size/anterior portion length
 $100B_L/AP_L$ 100 x blade length/anterior portion length

RESULTS

Phylogenetic Analysis

The ML analyses based on a 693-bp fragment of the mitochondrial *cox1* gene yielded the tree shown in Fig. 4. The BI analyses arrived at an identical topology ($-\ln L = -1857.37$ for run 1; $-\ln L = -1855.35$ for run 2). Specimens from Saint Helena Island, which form a monophyletic group, were recovered within the clade formed by specimens from Angola, with high statistical support. Four sites were variables in the sequences of the specimens from Saint Helena Island, and all nucleotide substitutions occurred in the third codon position.

Since specimens from Saint Helena form a clade whose closer sister group taxa are species from Angola, and these

Species	Locality	GenBank accession N°	Voucher N°
<i>Varioconus chytreus</i>	Baia da Lucira, Angola	KU892090	MNCN/ADN 86679
<i>Lautoconus dorotheae</i>	W coast of Madeleine Is., Dakar, Senegal	KJ550548	MNHN IM2009-8702
<i>Varioconus franciscoi</i>	São Nicolau, Angola	KU892089	MNCN/ADN 86678
<i>Lautoconus hybridus</i>	Dakar, Senegal	KJ550301	MNHN IM2009-18301
<i>Africonus infinitus</i>	Maio Is., Cape Verde	AY588187	Duda & Rolán (2005)
<i>Africonus irregularis</i>	Boa Vista Is., Cape Verde	AY588188	Duda & Rolán (2005)
<i>Africonus josephinae</i>	Boa Vista Is., Cape Verde	AY588190	Duda & Rolán (2005)
<i>Varioconus jourdani</i>	Saint Helena Island	KU892095-99, KU892100-01	MNCN/ADN 86684-85, 87-91
<i>Varioconus lobitensis</i>	Baía Farta, Angola	KU892094	MNCN/ADN 86683
<i>Africonus longilineus</i>	Sal Is., Cape Verde	AY588193	Duda & Rolán (2005)
<i>Africonus luquei</i>	Boa Vista Is., Cape Verde	AY588195	Duda & Rolán (2005)
<i>Africonus maioensis</i>	Maio Is., Cape Verde	AY588199	Duda & Rolán (2005)
<i>Lautoconus mercator</i> (1)	Dakar area, Senegal	KJ550378	MNHN IM2009-19232
<i>Lautoconus mercator</i> (2)	Dakar area, Senegal	AY588200	UMMZ 301996
<i>Varioconus micropunctatus</i>	Baía da Lucira, Angola	KU892092	MNCN/ADN 86681
<i>Lautoconus pineaui</i>	Dakar, Senegal	KJ550412	MNHN IM2009-19240
<i>Varioconus trovaii</i>	Baía da Lucira, Angola	KU892088	MNCN/ADN 86677
<i>Varioconus variegatus</i>	Inhamangano, Angola	KU892091	MNCN/ADN 86680
<i>Lautoconus ventricosus</i>	Gulf of Gabes, Tunisia	KJ550006	MNHN IM2009-18301
<i>Varioconus zebroides</i>	Sao Nicolau, Angola	KU892093	MNCN/ADN 86682

Table 1. List of species, locality of collection, GenBank accession numbers (new sequences in bold) and voucher numbers.

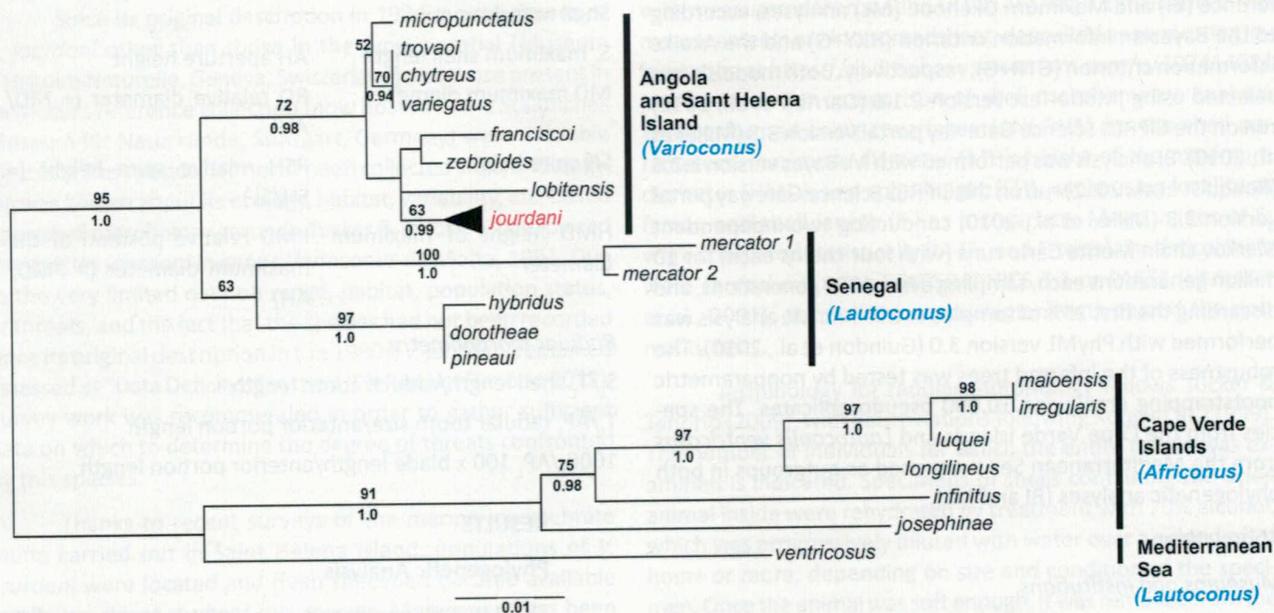


Fig. 4.- Phylogenetic relationships of *V. jourdani* from Saint Helena Island (7 individuals) and other West African cones inferred from mitochondrial *cox1* gene using ML and BI analyses. Numbers on each branch represent support values for ML (bootstrap proportions, up) and BI (posterior probabilities, down), respectively. Only support values above 50 % bootstrap proportions or 0.90 Bayesian posterior probabilities are shown. Scale bar indicates substitutions per site.

are ascribed to genus *Varioconus*, it is reasonable to name the cone species from Saint Helena as *Varioconus jourdani*, a combination that was already proposed by Tucker & Tenorio (2009). Cones from the Mediterranean Sea and those endemic from Senegal were considered congeneric by Tucker & Tenorio (2009), and placed in genus *Lautoconus*. However, the reconstructed phylogenetic tree indicates that this genus is paraphyletic. One possible taxonomic interpretation is that the cones from Senegal actually belong to genus *Varioconus*, which thus defined would become a larger taxonomic unit including many species from mainland Africa. Alternatively, we may consider the introduction of a new genus for the placement of the endemic cones of Senegal as a sister group to the endemic cones from Angola. Molecular and morphological studies, currently in progress, would help in disentangling the question. In any case, since *L. ventricosus* is the type species for genus *Lautoconus*, this genus would only be applicable to the species from the Mediterranean and neighboring Atlantic. The phylogenetic relationships between *L. ventricosus* and the endemic cones of Cape Verde are also being currently studied in detail.

To summarize, as a result of this phylogenetic study we can conclude that all specimens from Saint Helena clustered together with no clear group separation among individuals from different populations in the island, this being consistent with one single species hypothesis. Saint Helena Island cones are closely related to endemic cones from Angola, and hence they should be ascribed to the taxon *Varioconus jourdani*.

SYSTEMATICS

Family CONIDAE Flemming, 2009

Subfamily CONINAE Tucker & Tenorio, 2009

Genus *Varioconus* da Motta, 1991

Varioconus jourdani (da Motta, 1984)

Fig. 2; Plates 1 and 2

Type material: Holotype (MNHG 983.575; 28.2 x 18.5 mm, Fig. 2). 4 paratypes deposited in several institutions: paratype 1 (30 x 21 mm); paratype 2 (30 x 19.7 mm); paratype 3 (30.2 x 20 mm); and paratype 4 (29.7 x 19.7 mm).

Type locality: Lot's Wife Pond, South Side (Windward) of Saint Helena Island (UK), South Atlantic.

Material examined: More than 25 live-collected specimens from two separate populations. See Fig. 3 for localities. The examined specimens are in the MSF collection, and in the reference collections of the first and second authors.

Distribution and habitat: Endemic to Saint Helena Island, with several separate populations known. Reports of this species from Ascension Island are unreliable at this stage. There are two specimens of dead, worn shells resembling *V. jourdani* at the SMNS with labels that state "Ascension Island" as locality, but with no additional information. Divers report a slender variation, predominantly found along the north coast of the island, in groups of several individuals on rocks in turbulent water at 10-12 m. Isolated individuals of a broader form, more closely resembling the type material, are found isolated at 30-35 m on and among rocks, in quieter areas to the south of the Island. There is no other cone snail species living in direct sympatry with *V. jourdani*.

Description of the shell: Morphometric parameters: L = 21 – 31 mm; average L = 28 mm; RD = 0.66 – 0.78; RSH

= 0.13 – 0.21; PMD = 0.82 – 0.87. Moderately small, solid, compact, broadly and ventricosely conical shell. The sides of the last whorl are straight, convex below the shoulder. The shoulder is rounded, and the spire moderately elevated with straight profile. The surface of the last whorl is smooth above the base. The spire whorls are usually convex, covered with very fine arcuate radial hairlines. Cords are absent. Protoconch not studied due to erosion, but assumed to be paucispiral. The ground color of the shell is bluish-white with a variable number of patterned zones, usually below the shoulder, in the center and in the lower third; there is a great variability in the color and in the extension of the pattern, with dark brown being the most common, but also orange-brown or pinkish. The ground-color areas may appear speckled with dots and/or irregular fine axial lines; the spire whorls usually exhibit brown or orange-brown blotches. The aperture is purplish-white in the inside, with the internal margin of the lip stained purple interrupted by two narrow white bands, one at the height of the shoulder and the other at the lower third. The periostracum is pale yellow and translucent. The operculum is small, elongated (Fig. 5), and typical of a *Varioconus*. Most shells found alive are incrustated with calcareous algae.

Living animal and radula: A freshly preserved animal was of reddish brown color with numerous minute paler specks. The tentacles are black, the eye stalks reddish. 38 to 43 teeth in radular sac. Radular tooth (Fig. 6) of medium size ($S_L/T_L = 47 - 53$), with a short, pointed barb and with the anterior section equal or slightly shorter than the posterior section of the



Fig. 5.- Operculum of *V. jourdani* from Black Rock, South Saint Helena Island, 25-35 m depth. S_L 30.0 mm

tooth ($T_L/AP_L = 2.0 - 2.3$). Waist evident. Blade rather indistinct covering most of the anterior section ($100B_L/AP_L = 64\% \text{ to } 81\%$). 23 – 29 denticles in serration, arranged in one row in the apical portion, becoming 2-3 rows below, ending in a rounded terminating cusp. Base large, with a basal spur.

Comparisons: In the original description, this taxon was considered most similar to *Lautoconus taslei* (Kiener, 1850) (Fig. 7A). This species is pear-shaped, with a swollen shoulder strongly attenuated towards the base. However, the background color is greenish-yellow, with two whitish spiral bands, while the aperture is dark purple. *V. jourdani* was also compared to *Conus olivaceus* Kiener, 1850, now considered a synonym of *L. taslei*, and to *Conus damottai* Trovão, 1979 (endemic to the Cape Verde Islands) and *Conus orri* Ninomiya & da Motta, 1982 (Fig. 7B). Actually, according to the phylogenetic study, all these species, placed in the genera *Lautoconus*

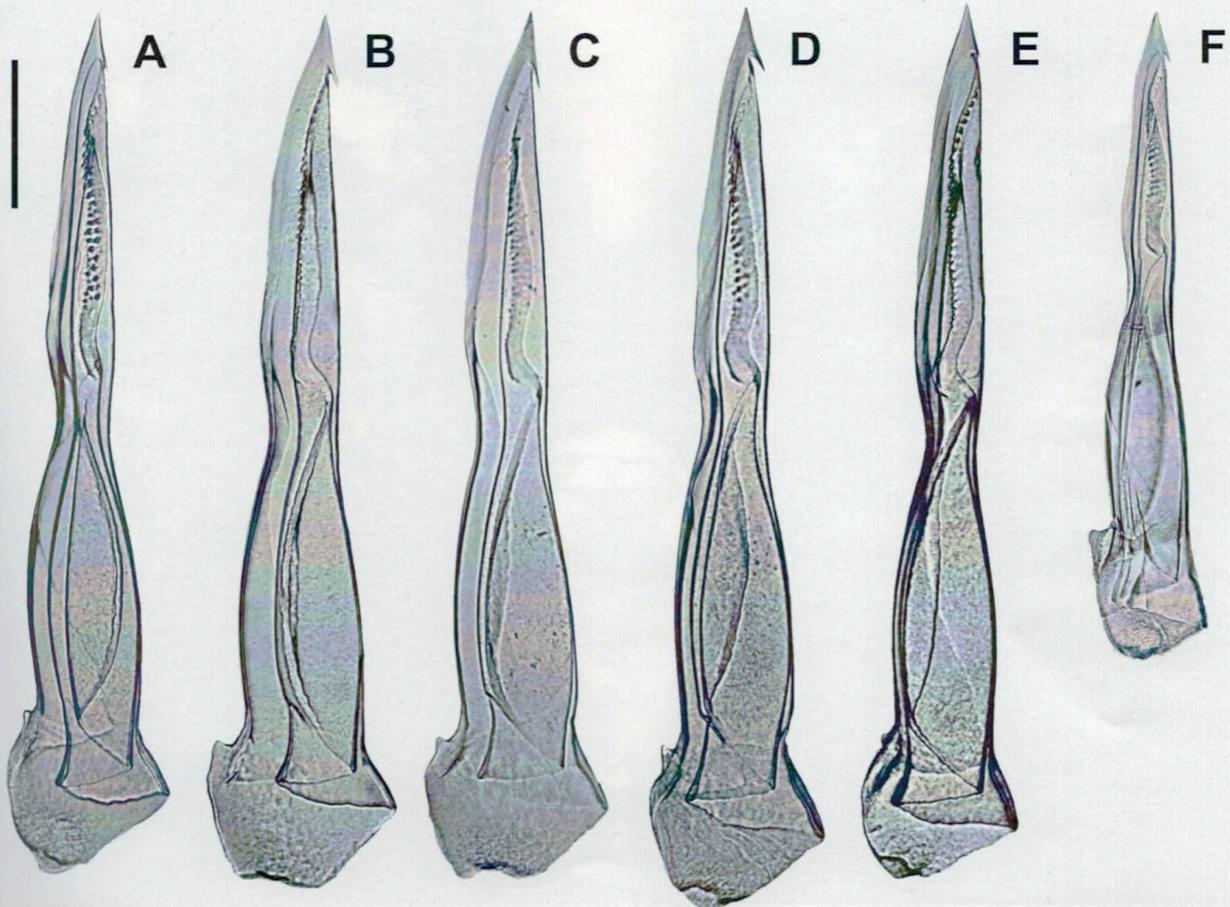


Fig. 6.- Radular teeth of *V. jourdani* from Black Rock, South Saint Helena Island, except F (Flagstaff Bay, North Saint Helena Island). A) S_L 27.1 mm; B) S_L 30.1 mm; C) S_L 29.9 mm; D) S_L 30.3 mm; E) S_L 28.7 mm; F) S_L 22.9 mm. Bar scale = 0.1 mm.



Plate 1.- 1-8 *Varioconus jourdani* (da Motta, 1984), Flagstaff Bay, Saint Helena Island, 10-15 m depth. 1a-b, 24.0 mm; 2 28.2 mm; 3a-b 22.6 mm; 4a-b 24.7 mm; 5 28.7 mm; 6a-b 21.1 mm; 7a-b 22.9 mm; 8 16.8 mm. 1 to 6 in MSF collection; 7 and 8 in MJT collection.

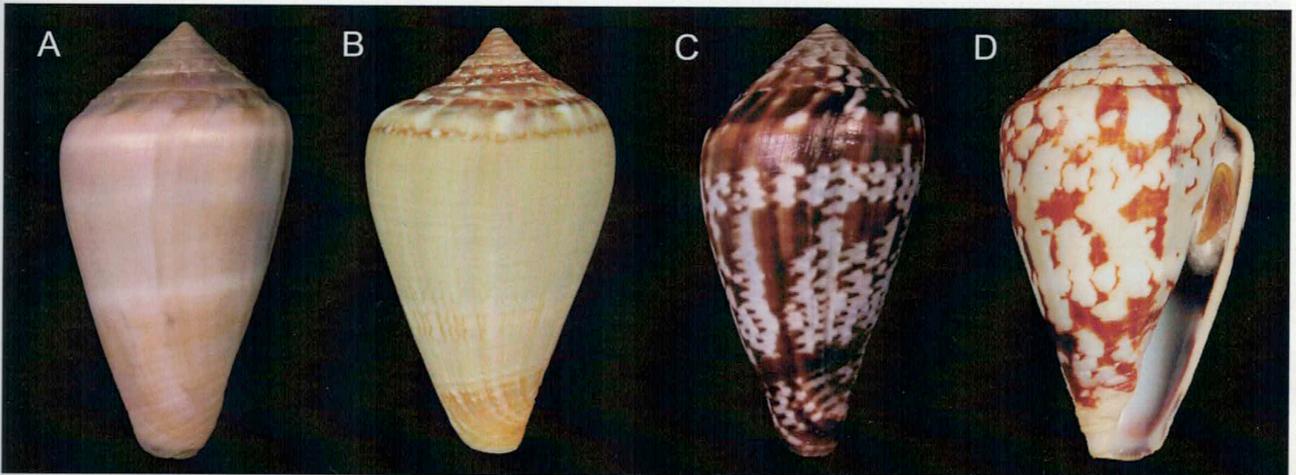


Fig. 7.- A) *Lautoconus taslei* (Kiener, 1850), 38.7 mm, Joal Fadiouth, Senegal, MJT collection; B) Paratype 3 of *Conus orri* Ninomiya & da Motta, 1982, 30.2 mm, Bojol Island, Gambia, SMNS collection; C) *Varioconus aemulus* (Reeve, 1844), 41.6 mm, Baía do Mussulo, Luanda Province, Angola, MJT collection; D) *Varioconus xicoi* (Röckel, 1987), 29.8 mm, Praia de Santiago, Luanda Province, Angola, MJT collection.

and *Africonus*, are only distantly related to *V. jourdani*. The cone species from Angola most similar to *V. jourdani* in terms of shell morphology are possibly *Varioconus aemulus* (Reeve, 1844) (Fig. 7C), and also *Varioconus xicoi* (Röckel, 1987) (Fig. 7D). The former is narrower-bodied than *V. jourdani*, whereas the latter has a distinctive angulate or subangulate shoulder, rather than rounded.

Remarks: The shell of *V. jourdani* exhibit the characters observed in other species of the genus *Varioconus*, namely the absence of cords on the sutural ramp and the rounded, indistinct shoulder. Likewise, the radular tooth morphology is fully consistent with the placement in this genus. We have studied specimens from two different populations, from the north and south of the island respectively. These correspond

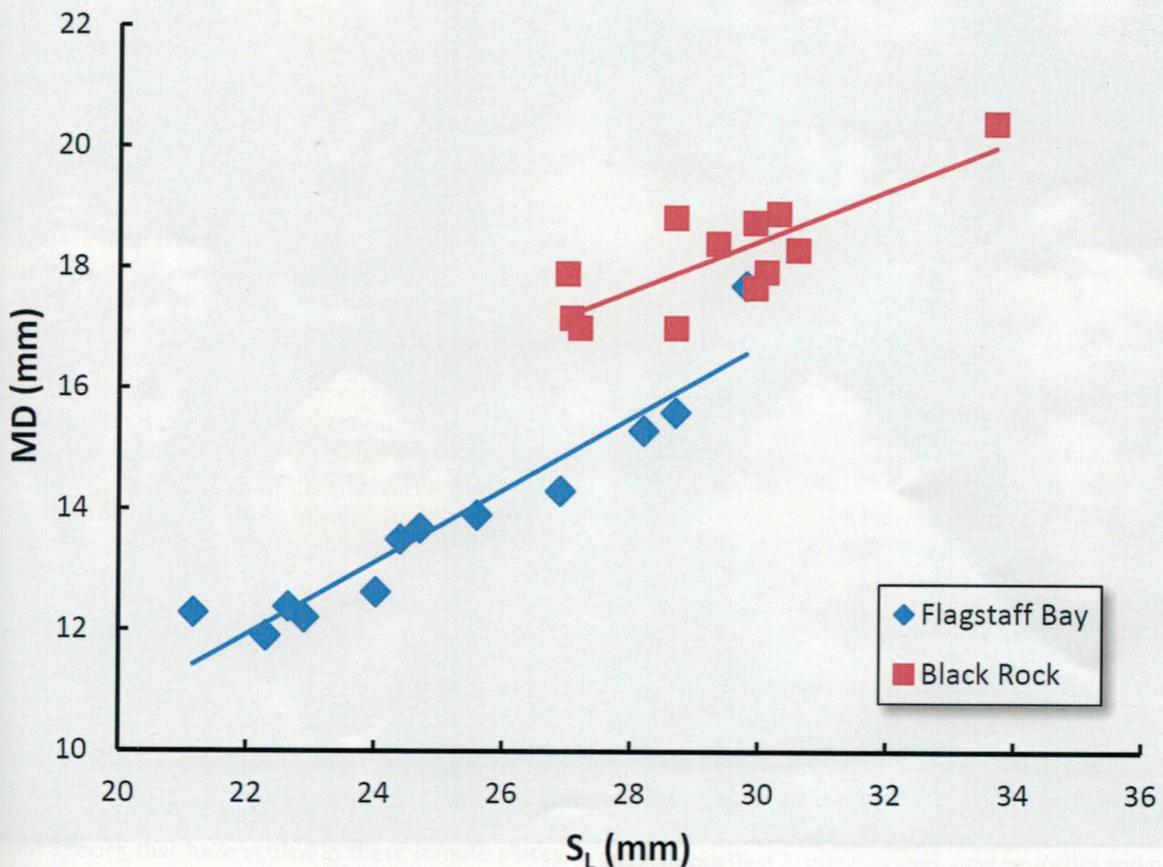


Fig. 8.- Plot of MD versus S_L for individuals from northern and southern populations of *V. jourdani*: Flagstaff Bay (♦) and Black Rock (■).



Plate 2.- 1-8 *Varioconus jourdani* (da Motta, 1984), Black Rock, Saint Helena Island, 25-30 m depth. 1a-b, 27.1 mm; 2a-b 29.4 mm; 3a-b 30.1 mm; 4a-b 29.9 mm; 5a-b 30.3 mm; 6a-b 28.7 mm; 7a-b 29.9 mm; 8a-b 27.2 mm. MSF collection.

respectively to two shell morphotypes, one being more slender, and the other more inflated. The difference in the MD/S_L ratio between the two populations is clearly shown on the plot represented in Fig. 8.

Additional material from different places and depths around the island will be necessary to ascertain the consistency of this observation. Although the number of individuals studied is insufficient to draw any solid conclusion, a statistical comparison between the individuals from the northern and southern populations revealed significant differences in S_L ($t = 4.425$, $p = 0.00021$; $U = 13.5$, $p = 0.00081$) and in MD (ANCOVA on MD, population locality as factor, and S_L as covariate: $F = 38.98$, $p = 0$). Thus, specimens from Flagstaff Bay (Plate 1) have a smaller mean S_L (25.1 mm *versus* 29.4 mm) and are significantly narrower-bodied than those from Black Rock (Plate 2). The former exhibit a more constant, darker color pattern (although with exceptions, i. e. Plate 1, Fig. 5) than the specimens from the south of the island, which are far more variable and exhibit lighter, more vivid colors (uniform pale pink in some cases). There are also differences in radular morphometry (Fig. 6F; in parameters T_L/AP_L and 100B_L/AP_L), but the radula was only examined in one specimen of this population. The north and south populations, however, were not resolved molecularly using *cox1* alone. For the time being, we consider the individuals of these two populations conspecific, and within the variability of the single taxon *V. jourdani*. Having merely a single species in different habitats around Saint Helena Island agrees with the situation in the Canary Islands, where the variable *Lautoconus guanche* (Lauer, 1993) is spread throughout the different islands of the archipelago (Cunha et al. 2014). However, further studies and examination of more individuals from different populations around the island might eventually afford sufficient information providing support for an alternative species hypothesis, i.e., multiple species and the occurrence in Saint Helena Island of a species radiation process similar to that observed in other oceanic archipelagos like the Cape Verde Islands (Cunha et al. 2005; Duda & Rolán 2005).

The majority of the gastropod species recorded by Brown (2014) indicates that Saint Helena Island was populated mainly by West African species. This is easily explained by prevailing ocean currents in this part of the Atlantic. The Benguela, or South Equatorial current, carries warm surface water along the coast of Angola northwards, and then moves west in to the Atlantic. An Equatorial counter current, running in west to east direction separates the Benguela from the northern Equatorial current. The species of Cassidae, Ranellidae and Bursidae are conchologically inseparable from their West African populations, and most of them are amphi-Atlantic. The two species of Cypraeidae present in Saint Helena Island are of West African origin, with the closest relatives in the Cape Verde Islands, but both have developed distinct features (*Naria spurca sanctaehelena* (Schilder, 1930) and *Luria lurida oceanica* (Schilder, 1930)). Their molecular data suggest a close relationship, but in isolation, supported by their distinctive shells, which allow a safe distinction from West African populations of their respective relatives (Dr. Christopher P. Meyer, pers. comm. with the second author, 2015). Many of the Gastropods of Saint Helena Island also occur at Ascension Island, which is an indication that those species that have settled in these remote places have long-lasting veliger stages, and have arrived to Ascension

Island rather recently, possibly with Saint Helena Island as a stepping-stone. The arrival of species from the opposite direction, from the Caribbean or South America, via Ascension, to Saint Helena Island has apparently not happened. The question is how the ancestor of *V. jourdani* initially got to this remote place, and when. Dating analyses based on molecular phylogenies with more taxa and genes are essentials to answer these questions. Unfortunately, no egg-capsules or specimens of *V. jourdani* with a well preserved protoconch are available to us at this point to allow conclusions on its mode of development. Whether *V. jourdani* has become an intracapsular developer, or if it retained a planktonic phase may become an important aspect once the status of its two morphologically divergent populations can be ascertained.

ACKNOWLEDGEMENTS

We wish to thank Dr. Judith Brown, manager of the Darwin Marine Biodiversity and Mapping Project, Environment and Natural Resources Directorate, Saint Helena Government, David Jenkins, and Richard Moors, who supplied the specimens and information on its habitat, and the Molluscan Science Foundation, Inc. (MSF, Owing Mills, MD, USA). Many thanks also to Dr. Christopher P. Meyer (Smithsonian-National Museum of Natural History, Washington D. C., USA). Our most sincere thanks to: Prof. Rafael Zardoya (MNCN-CSIC, Madrid, Spain) and Michael A. Mont for the valuable suggestions and constructive criticism made upon reading the manuscript. Sequencing was funded by the project CGL2013-45211-C2-2-P from the Ministerio de Economía y Competitividad of Spain to Rafael Zardoya.

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