

Juvenile limpets hitchhiking on top of the shells of adults on La Palma, the Canary Islands (Patellogastropoda: Patellidae)

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Jonge schaalhorens die meeliften bovenop de schelpen van volwassen dieren op La Palma, Canarische eilanden

Samenvatting. De auteur beschrijft het voorkomen van juveniele schaalhorens die meeliften bovenop de schelp van volwassen dieren op het eiland La Palma, Canarische Eilanden. Dit gedrag is goed bekend van Patellidae van zuidelijk Afrika. De auteur biedt de meest waarschijnlijke onderliggende reden van dit gedrag: een territoriale houding jegens andere schaalhorens in verband met schaarste aan voedselbronnen en leefruimte. Aanvullend biedt de auteur een korte beschrijving van geslacht en geslachtswisseling bij Patellidae en voert aan dat de liftende juvenielen waarschijnlijk hoofdzakelijk mannetjes zijn.

Summary. The author describes the occurrence of juvenile limpets that hitchhike on top of the shells of adult animals on the island of La Palma in the Canary Islands. This behavior is well-known from Patellidae species from southern Africa. The author offers the most probable underlying reason for this behavior: a territorial attitude against other limpets due to limited food sources and living space. Furthermore, the author briefly discusses sexes and sex change in Patellidae and argues that hitchhiking juveniles are probably predominantly male.

Introduction

In 2007, during a stay on the rugged island of La Palma, I had the pleasure to meet Mr. Juan Manuel Castro Martin. He was a genuine 'palmero' who possessed much knowledge of the archaeological and paleontological heritage of La Palma. In addition, he was a keen botanist who could identify each plant and tree that rooted on the volcanic soil of the island. Furthermore, he was very interested in mollusks, both land and marine, and limpets could count on his special attention. He had gathered many specimens of limpets, either from the rocky coast or from kitchen waste of restaurants. After all limpets, locally called 'lapas', are used as a food source. Juan himself was a modest connoisseur. I have several specimens in my private collection which originate from his dinner plate. During my visit Juan showed me shells of adult limpets with juveniles herding on top of them. Other limpet shells bore the scars of smaller limpets that took a free ride. Were these youngsters hitchhiking? I was familiar with this phenomenon as it is common practice among several limpet species from southern Africa. Apparently, this phenomenon also occurs on La Palma. I felt astonished by these shells since I had never found any 'evidence of good parenthood' among the limpets that I encountered during my collecting trips to Macaronesia comprising the Canary Islands, the Azores, Madeira and the Cape Verde Islands. What causes this behaviour? In order to shed some light on this peculiarity we need to travel from La Palma to southern Africa and even further.

A hitchhiker's guide through the galaxy of Patellids: herding, gardening and sex change

The southern African coastline houses the largest number of limpet species in the world. These slow-moving browsing animals feed on algae, lichens and diatoms. They are predominantly intertidal or infratidal, and are zoned fairly rigidly both vertically and geographically (Branch, 1971). In general, the populations display a large number of individuals. In particular *Scutellastra cochlear* (Born, 1778) lives in large densities, often up to 1700

individuals per square meter. The zone occupied by this species is aptly named the Cochlear zone. It is obvious that the limiting resources on the rocks must be space and food. Therefore, the animals of *S. cochlear* are strongly territorial. They combat their neighbors as well as their own offspring. The latter have to call for drastic measures: they flee the 'battleground' and climb the shells of adult animals. There 'uphill' they dig a foxhole and stay put. Four or five young specimens on one adult is not a rarity. Sometimes one can even observe youngsters from different species attached to an adult specimen. As the young animals grow they make a scar in the shell of their host. After a while it becomes increasingly difficult for the youngsters to remain on top of the adult's shell. At one point they have to find their own place on the rocks among the adult specimens. Many juveniles die in that process. Apart from *S. cochlear* this behaviour can also be observed in other limpets like *Cymbula granatina* (Linnaeus, 1758), *Scutellastra granularis* (Linnaeus, 1758), *S. flexuosa* (Quoy & Gaimard, 1834) and *S. longicosta* (Lamarck, 1819). Juveniles of the latter species can also be found hitchhiking on outsiders like *Oxistele sinensis* (Gmelin, 1791) (Branch, 1971). In order to shed some light on this herding behaviour we have to get familiar with Patellid behaviour. Limpets occupy fixed positions. From these they undertake feeding excursions (Branch, 1971). After feeding on the algae the individual returns to its own particular spot where it creates, in due time, a permanent home depression. This is called 'homing behaviour'. *S. cochlear* raised this concept to a higher level. The snail is intimately associated with 'gardens' of specific algae. Each individual is surrounded by its own garden of fine red, turfing algae, mainly the red algae *Herposiphonia heringii* Falkenberg, 1901 and *Gelidium micropterum* Kützting, 1868. During grazing, the animal revolves slowly around its axis. Therefore the garden is groomed evenly. In this way the energy requirement of the animal keeps pace with the growth rate of the algae (Plagányi & Branch, 2000). Adolescent *S. cochlear* who vacate the shells of their hosts have no garden of their own.

They only survive if they manage to occupy a zone covered with the red algae species *Spongites yendoi* Y. M. Chamberlain, 1993 which is considered less palatable by the adult limpets. The adolescents do not cultivate gardens in the *S. yendoi*-zone. Only if a prime location becomes vacant due to mortality among the elderly, adolescents abandon the *S. yendoi*-zone and occupy the untenanted privileged spot. There they immediately start to maintain their own garden with tastier algae (Heller, 2015). This 'gardening habit' is also observed in other *Scutellastra* species such as *S. mexicana* (Broderip & G. B. Sowerby I, 1829) from the Pacific coast of Central America, *S. kermadecensis* (Pilsbry, 1894) from the Kermadec Islands, *S. tabularis* (Krauss, 1848) and *S. longicosta*, the latter two both from South Africa, *S. laticostata* (Blainville, 1825) mainly from Western Australia and *S. flexuosa* from the Indo-Pacific region.

When we focus on Patellid reproduction and recruitment, hermaphroditism appears to be an option (Henriques *et al.*, 2016). Hermaphrodites yield both male and female offspring. Hermaphrodites may be sequentially or simultaneously male and female. There are different sex-changes possible: male to female (protandry), female to male (protogyny), female to hermaphrodite (protogynous hermaphroditism), and male to hermaphrodite (protandrous hermaphroditism).

The rules governing sex change are diverse and can differ between species. In general sex change is genetically controlled, but environmental factors will exert influence on the process. It is known, for instance, that a certain number of large females in a population can postpone sex change in males (Henriques *et al.*, 2016: 77). Lindberg (2007: 221) mentioned that females of *S. flexuosa* were most common in the larger size classes. Creese *et al.* (1990) studied *S. kermadecensis*, a large-sized, endemic species from the Kermadec Islands, 750 km northeast of New Zealand. According to their studies protandric sex change is manifest in the species. Small specimens happen to be predominantly male, while half of the larger ones are female. Females were most common in the larger size classes. As mentioned earlier *S. kermadecensis* is also known to harbor hitchhikers riding on top of large shells. At some point these predominantly male youngsters have the ability to change sex. Creese *et al.* (1990) pointed out that sex change coincides largely with the moment that the hitchhikers abandon the shell of their host. So, there is reason to assume that most hitchhikers are predominantly male.

La Palma: commercial exploitation, phylogeographic studies and nomenclature

The Canary Islands comprise seven large islands in the Atlantic Ocean, approximately 100 kilometers west of Morocco. La Palma is the northwesternmost of all islands in the archipelago. It boasts natural beauty which triggered the establishment of a 'Biosphere Reserve' in 1983. The reserve was extended and at present it encompasses the entire island. In 2001 a marine reserve was established at the southwestern side of the island. I visited La Palma several times in order to dive and snorkel its coastal waters. My main interest is the members of the Conidae and the Patellidae. If one wants to acquire the latter one can examine the wave battered rocks or, as Juan used to do, visit one of the local restaurants and order a dish of grilled limpets with mojo sauce and keep the emptied shells. Although nowadays

this delicacy comes at a price: the Patellidae-stocks endure the consequences of commercial exploitation, pollution and habitat removal. This applies to all species that can be found on La Palma and the other islands in Macaronesia (Martins *et al.*, 2008; Martins *et al.*, 2017). The current management measures are inadequate and biodiversity is under threat. Conservation efforts are somewhat hindered by the fact that the taxonomic status of the 'species' remained unclear; in particular the status of the so-called *Patella candei* d'Orbigny, 1840 complex (Christiaens, 1974; Titselaar, 1998). But the argument could subside. Recent phylogeographic studies have identified genetically distinct stocks in the Macaronesian archipelago (Carreira *et al.*, 2018). The latter authors recommended to elevate all four subspecies of the *P. candei* complex to full species rank. In my opinion the following names should be used: *P. candei* d'Orbigny, 1840 (predominantly Selvagens), *P. gomesii* Drouët, 1858 (Azores), *P. tenuis* Gmelin, 1791 (Madeira) and *P. ordinaria* Mabille, 1888 (Canary Islands) (Titselaar, 2019). A better understanding of species delineation and identification has the potential to improve conservation measures.

La Palma hitchhikers

Three limpet species live throughout the rocky intertidal zone of La Palma. The species show vertical zonation. In general, three intertidal zones can be distinguished: high, intermediate and low. *Patella piperata* Gould, 1846 mainly lives in the high intertidal zone. *P. ordinaria* tends to dwell in the intermediate and low intertidal whereas *P. ulyssiponensis* has a clear preference for the low intertidal. The three species forage on algae that cover the rocks. In comparison to their relative *Scutellastra cochlear* they do not exert gardening and they do not tend to live in densely packed quantities. *P. ulyssiponensis* seems to mirror the habit of harboring hitchhiking juveniles. Furthermore, the shells bear many other organisms including many algae. This 'epibiota' assemblage can vary. Faria *et al.* (2013) collected *P. ulyssiponensis* in the Azores and found a very rich hitchhiker community of algae and invertebrates. The authors were able to identify 192 different species and postulated that the habitat provided by the shells functions as a sanctuary in an area where algae communities are controlled by limpets.

The adult limpet shells with attached juveniles found by Juan Castro Martin belong to two species: *Patella ordinaria* and *P. ulyssiponensis*. I did not receive nor possess specimens of *P. piperata* with hitchhikers. I only received the empty shells and therefore I am not able to study the original residents. It is striking that all the youngsters who take a free ride belong to *P. ulyssiponensis*. I do not hold a single adult specimen of *P. ordinaria* with their own kind on top, nor did I receive a *P. ulyssiponensis* bearing a juvenile *P. ordinaria*. This is either a coincidence due to my limited number of samples (seven samples of *P. ulyssiponensis* and two samples of *P. ordinaria*) or a reflection of the fact that *P. ulyssiponensis* is the only local species that spawns juveniles with an appetite for hitchhiking. Martins *et al.* (2017) state that *P. ulyssiponensis* is a protandrous species. The species has an early pure male reproduction and later a reproduction in both sexes. This could lead to the assumption that the hitchhiking juveniles of *P. ulyssiponensis* are male. Cunha *et al.* (2007) described simultaneous hermaphroditism in the Azorean endemic limpet *P. gomesii* which had been considered to be a gonochoristic species

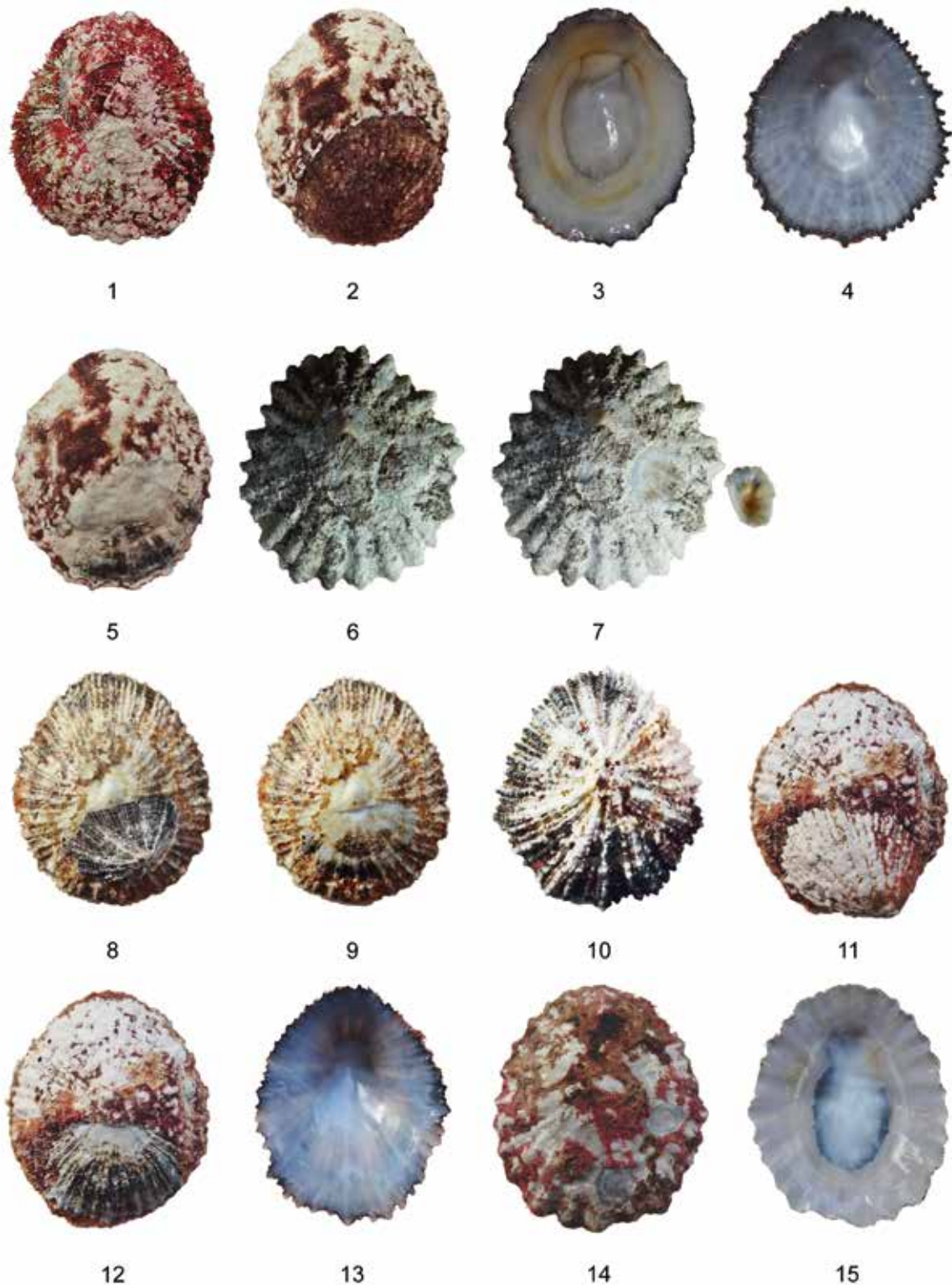


Fig. 1. *Patella ulyssiponensis* La Palma, Los Sauces, Punta Talavera. Adult with juvenile. Exterior. L 60 mm; W 52 mm; H 21 mm. Juvenile L 20 mm; W 18 mm; H 6 mm. **Fig. 2-5.** *Patella ulyssiponensis* La Palma, Santa Cruz de La Palma, Los Cancajos, Cala Norte, Punta de la Vestinga. Collected snorkeling. Depth 1.5 m. **Fig. 2.** Adult with juvenile. Exterior. **Fig. 3.** Interior. **Fig. 4.** Interior juvenile. L 30 mm; W 21 mm; H 13 mm. **Fig. 5.** Adult without juvenile. L 51 mm; W 39 mm; H 19 mm. **Fig. 6-7.** *Patella ordinaria* La Palma, Garafía, Local Fishermen. Delivery Restaurant 'Salta si puedes'. **Fig. 6.** Adult with juvenile *P. ulyssiponensis*. Exterior. L 66 mm; W 60 mm; H 19 mm. **Fig. 7.** Exterior with detached juvenile. L 17 mm; W 10 mm; H 4 mm. **Fig. 8-10.** *Patella ulyssiponensis* La Palma, Santa Cruz de la Palma, Los Cancajos. Collected snorkeling. Depth 1 m. On concrete boulders. **Fig. 8.** Adult with attached juvenile. Exterior. L 61 mm; W 51 mm; H 24 mm. **Fig. 9.** Adult with detached juvenile. **Fig. 10.** Juvenile. L 25 mm; W 20 mm; H 9 mm. **Fig. 11-13.** *Patella ulyssiponensis*. Santa Cruz de la Palma, Los Cancajos. Collected snorkeling. Depth 1 m. On concrete boulders. **Fig. 11.** Adult with attached juvenile. Exterior. L 58 mm; W 49 mm; H 19 mm. **Fig. 12.** Adult with detached juvenile. **Fig. 13.** Interior juvenile. L 34 mm; W 28 mm; H 12 mm. **Fig. 14-15.** *Patella ordinaria*. La Palma, Los Sauces, Punta Talavera. **Fig. 14.** Adult exterior with two scars. Most probably of juvenile *P. ulyssiponensis*. **Fig. 15.** Interior. L 67 mm; W 56 mm; H 18 mm. All photographs are by the author.

(i.e., having separate sexes). Simultaneous hermaphrodites are organisms which have both male and female sexual organs. Sousa *et al.* (2019) confirmed the occurrence of sequential hermaphroditism in *P. piperata*. Whether youngsters of *P. ordinaria* hitchhike and if so are predominantly male remains unclear. Henriques *et al.* (2011) and Sousa *et al.* (2017) studied *P. ulyssiponensis* and the *P. candei* complex [sensu Christiaens, 1974]. They suggested the existence of a specific nursery habitat. Juveniles would only migrate to the adult population after reaching a specific shell length/age. This might be the result of strong competition for space as observed in *S. cochlear*. Henriques *et al.* (2011) and Sousa *et al.* (2017) did not mention the hitchhiking phenomenon.

Discussion

While 'limpeting' I always keep an eye open for the hitchhike phenomenon. However, only once I found a single large adult *Patella vulgata* (Linnaeus, 1758) in Brittany with three small juveniles adhered to the side of it. As these youngsters had not imprinted a scar in their carrier's shell this might just be an example of accidentally crawling around instead of prolonged settling. I already stated that I myself never found any 'evidence of good parenthood' in Macaronesia. Furthermore, I never stumbled upon this peculiarity while investigating limpets in Aruba, Australia, Baja California, British Columbia, California, Indonesia, Oregon or wherever. Beware of the fact that one has to distinguish between hitchhiking juveniles and species that live on top of other species like for instance *Crepidula fornicata* (Linnaeus, 1758) or *Scurria parasitica* (d'Orbigny, 1846). The latter is a member of the Lottiidae and the species is always found on large fissurellids and chitons where it grinds deep scars in the shells of their involuntary hosts. These scars could be mistaken for scars produced by youngsters as described herein. If readers observed hitchhiking in European limpets I would appreciate to receive information.

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