A Study on Olive Shells – 3:
Juvenile or Adult? Prejudices, Evidence, a New Growth Model and Taxonomic Consequences

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ABSTRACT The cross-sections of several *Oliva mustelina* Lamarck, 1811, demonstrate that the presently accepted growth model for Olive shells needs profound revision. In fact, the cross-sections reveal peculiar hidden "rest-structures" which are formed on a yearly basis. The growth curve of *O. mustelina* can be determined by angular measurements of the rest-structures and statistical methods. The age of any single specimen — above all, if it is a juvenile, a sub-adult or a full adult — can be estimated by this growth curve combined with other external features of the shell. The taxonomic consequences of the new growth model are relevant. *Oliva virgata* Sterba, 2005, is an example of how a "new species" was named based upon the juveniles of another.

KEYWORDS Shell growth, Olive cross-sections, *Oliva mustelina*, *Oliva virgata*

INTRODUCTION

The majority of studies on mollusks' growth often examines the economically important species — like scallops or clams — and their relationship with the environment. How quickly an edible species reaches a determined size is important to regulate its fishing. Studies on other species, and in particular those of gastropods, are less common.

Growth patterns are visible on many bivalves and testify to their remarkable longevity. Gastropods display a wide array of shapes and sculptures, which may conceal growth patterns. The difference in juveniles is apparent in *Strombus*, whose adults exhibit large external lips. How old a conch can be, is another question. Cowries develop ventral toothed apertures which are lacking in juveniles and look immature in sub-adults. Again, how long a *Cypraea* can live, is another problem. But when does juvenile and sub-adult stages stop in a *Murex*, with the same number of similar varices per whorl? What about an *Epitonium*, with its regularly spaced ribs? And what about gastropods with relatively uniform surfaces, like *Conus* or *Terebra*? Besides the occasional study, gastropods' growth is mostly *terra incognita*.

Regarding the members of the genus *Oliva* Bruguiére, 1792, it is accepted that their shells develop at a decreasing speed, and that adults, sub-adults and juveniles are identifiable in a similar way to those of conchs. A young Olive has a sharp outer lip. The animal uses calcium carbonate to quickly increase its size. In a sub-adult the lip is no longer sharp, but remains thin. Growth speed is reduced and calcium carbonate is also used to reinforce the shell. Finally, in an adult, the lip is rounded and thick. Growth speed is almost null and calcium carbonate is only used to make the shell stronger. While plausible, this scenario is incorrect.

THE ACCEPTED GROWTH MODEL

Olives can live in aquariums and therein increase in size, mate and lay eggs. Sadly, the fact their larvae die shortly after hatching in captivity prevents the direct study of the mollusks' full development [Zeigler & Porreca 1969: 15-16]. Captive animals, however, are exempt from the seasonal cycles of their habitat. Their life span is shorter and their growth can be altered by maintaining a constant temperature, abnormal feeding and lack of nutrients. Therefore, aquarium observations do not offer a reliable description of what happens in nature. They can, nevertheless, reveal the animals' sensitivity to changes. For example, pattern variations can be artificially induced by modifying the color of the tank's substrate. Once placed on a light bottomed tank, a black

Oliva oliva (Linné, 1758) starts to develop a whitish shell [Tursch, Ouin & Bouillon 1995: 33-34; Tursch & Greifeneder 2001: 226-227]. Similar changes occur in nature when momentous events modify the sea-bed composition [cf. Goldberg 2016: 191-192].

A first attempt to determine growth stages dates back to 1969. In their work on the genus *Oliva*, Rowland F. Zeigler and Humbert C. Porreca showed X-ray pictures of *Oliva porphyria* (Linné, 1758), which helped to distinguish a "normal shell" from an "older shell" by the degree of "internal skeletal absorption". In a "normal" specimen all whorls were present. In an "older" one, the internal whorls were re-absorbed to create more room for the animal's soft parts [Zeigler & Porreca 1969: 7-8].
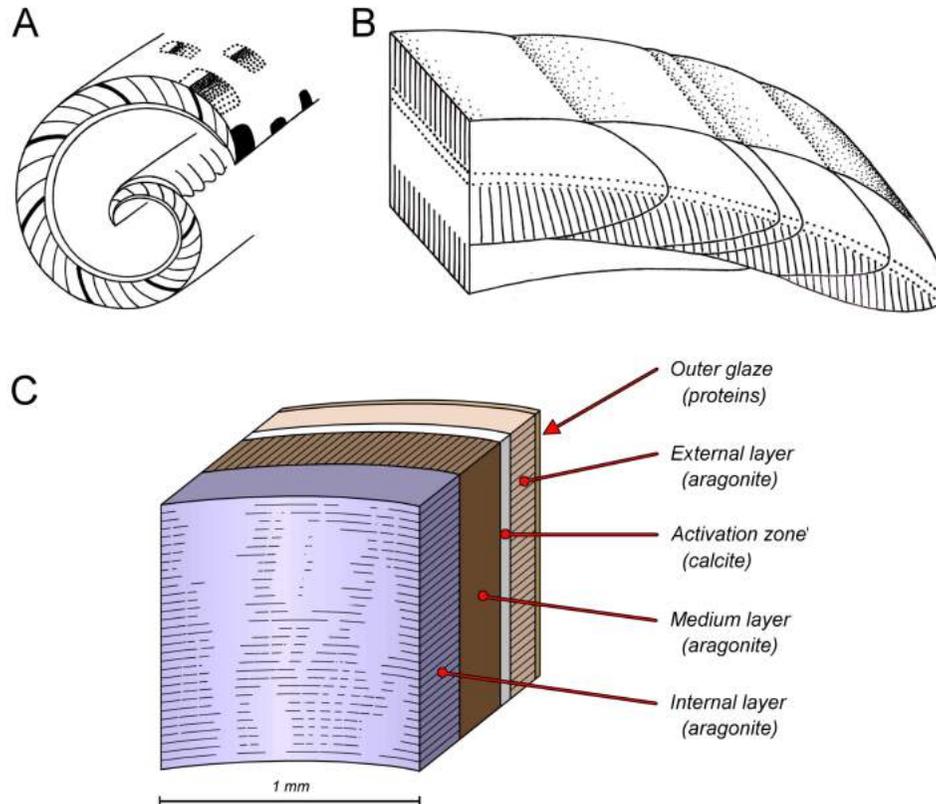
Figure 1. Olives' traditional growth model and shell structure: **A**. Shell cross-section from Greifeneder 1981: 80, fig. 21; **B**. Lip cross-section fromr Sterba 2005: 13, fig. 3; **C**. Four-layer shell structure.

In 1981, in his introduction to collected field studies on *Olividae* Latreille, 1825, Dietmar Greifeneder included a sketch of an Olive cross-section (*i.e.* perpendicular to the shell axis). The sketch outlines the extent of the internal skeletal absorption: only about 1.5 whorls survive the process. In addition, within a two-layer shell, "sloping growth stripes […] represent earlier edges of the outer lip" [Greifeneder 1981: 81]. The regularly spaced stripes bend towards the inside of the shell and support the concept of a progressive growth with a sharp lip (Figure 1A)[Ibid.: 80, fig. 21].

In order to devise a metric approach to the species, Bernard Tursch and Greifeneder reassessed the matter in 2001. The shell structure is easier to observe by cutting a few specimens. Within an up-to-date four-layer shell, a first glance to the figured cross-sections confirms the progressive growth, which had been synthesized in the 1981 sketch [Tursch & Greifeneder 2001: 106, fig. 7.03b; 113, fig. 7.19].

Finally, in his German (2003) and English (2004) monograph on *Olividae*, Gunther Sterba mostly relied upon the available growth model. One exception concerns the lip's profile: it does not slope, but rather forms a wedge. Its vertex is marked by the so-called "transition layer" of the shell [Sterba 2004: 11-13 and fig. 2]. Moreover, in mature specimens, the lip's area hosts a series of thick calcium carbonate segments interspaced by protein foils. The segments explain the longitudinal furrows observed outside the lip of *Oliva vidua* (Röding, 1798), and another few species (Figure 1B) [Ibid.: 12-13 and fig. 3].

In summary, notwithstanding marginal discrepancies, the growth model appears to be coherent and well accepted. On the one hand, it offers a handy method to separate juveniles, sub-adults and adults by just examining the lip.

On the other hand, the model suggests that nothing can be told about the age by only observing the shell.

The longevity of Olives is, by the way, relevant. By extrapolation from specimens maintained in an aquarium for a few months, Bernard Tursch, Jean-Marc Ouin and Jean Bouillon estimated that *Oliva oliva* lives at least 10 years [Tursch, Ouin & Bouillon 1995: 34]. By measuring the cyclic variation of molecular oxygen along cross-sections (more oxygen is present in cold than in warm water and, therefore, the material deposited within the shell is more or less rich in oxygen on a temperature/seasonal basis), Florentia Arrighetti and associates established that Olives' relative *Olivancillaria deshayesiana* (Ducros de Saint Germain, 1857) lives around 10 years [Arrighetti *et al.* 2012: 168]. As for the close family *Olivellidae* Troschel, 1869, after about a decade spent in re-picking up hundreds of marked specimens — a work that involved the members of the San Diego Shell Club — Rudolf Stohler came to the conclusion that *Olivella biplicata* (Sowerby I, 1825) lives between 8 and 12 years [Stohler 1969: 266].

But is it true that the lip's aspect is an indicator of an Olive's growth stage? And is there really no easier way to estimate the age of an Olive than studying populations, performing molecular analysis or undertaking decennial campaigns?

CROSS-SECTIONS FOR A CORRECT GROWTH MODEL

About one year ago, in an attempt to check the structure of Olive shells, I cut in half two *Oliva mustelina* Lamarck, 1811. As expected, the sections confirmed the multi-layer structure of the shell. Like other close relatives, *O. mustelina* is formed by four primary calcium

carbonate layers (Figure 1C). Below a protein glaze, the "external layer" is made of aragonite: tiny lamellae (ca. 25 per mm) laying in planes perpendicular to the shell axis. Together with the glaze, this layer contains the pigments which produce the shell's pattern. The second layer, usually called "transition zone", is made of white calcite. In a cross-section, it appears as a series of micro-cusps pointing to the lip. Its forward position during shell growth shows evidence that this layer plays the role of catalyzer for crystallization. It represents much

more than a "transition" and, from here on, it will be called the "activation zone". The third "medium layer" is, once again, made of aragonite, but its lamellae are parallel to the shell axis. The color depends on the species, and in *O. mustelina* it is brown. The fourth "internal layer" has the same composition and structure of the external one. The color depends on the species, and in *O. mustelina* it is deep violet [cf. Tursch & Greifeneder 2001: 125-132; cf. Sterba 2004: 9-11].
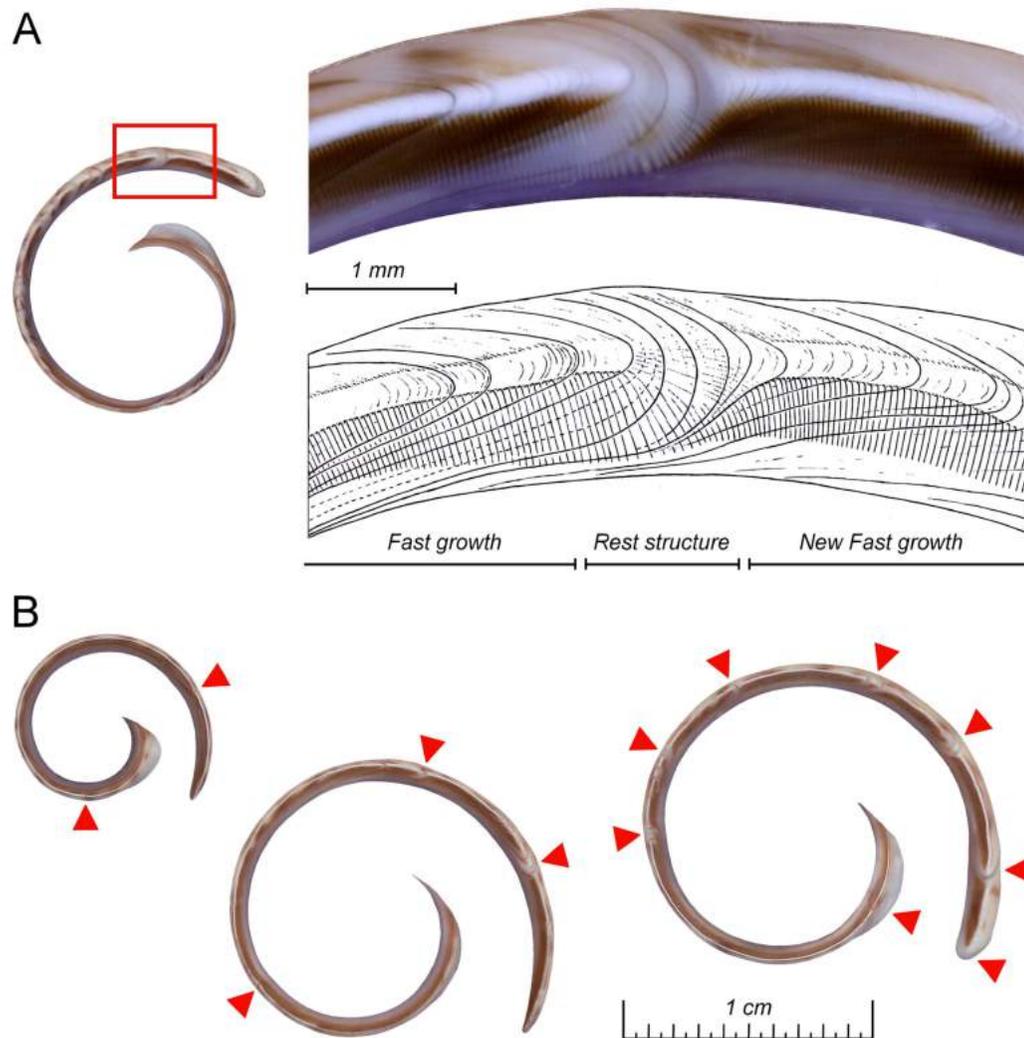
Figure 2. Cross-sections of *Oliva mustelina* Lamarck, 1811: **A**. Detail of a cross-section and its interpretation; **B**. Rest-structures in juvenile, sub-adult, and adult shells.

Unexpectedly, the cross-sections revealed features contradicting the accepted growth model. An accurate analysis of *O. mustelina*, and checks on other species, confirmed that such a model is wrong. The animal does not form the shell gradually, but rather through alternate phases of growth and rest. During growth, the shell's lip always looks like a wedge: the faster the growth, the sharper its angle. The white activation zone reaches the extremity of the lip. The internal and medium layers follow on both sides of the activation zone. Finally, the internal layer is deposited posteriorly. All together, the glaze, the external layer and the activation zone are about as thick as each one of the remaining two layers. Nearing the rest phase, the activation zone enlarges itself and pushes the external and medium layers respectively outwards and inwards. During this time, the shell thickens, while the compressed internal layer tends to disappear. The profile of the lip becomes round and, during rest, the majority of the cross-section is made of white calcite. When growth restarts, the lip is reshaped into a wedge (Figure 2A).

The alternate growth-rest phases are recorded within the shell in characteristic structures. The thickness of the protein foils deposited at the end of each phase, suggests that new shell formation does not take much time (perhaps a few weeks), and is followed by a relatively long rest. During growth, successive positions of the lip are always marked by protein foils: the animal in turn produces a foil of calcium carbonate crystals, which it then covers with a protein foil. During rest period, in the absence of new calcium carbonate, only proteins are deposited. Therefore, the longer the shell stays at rest, the thicker the last protein foil becomes. In the same way that the rings in trees, "rest-structures" appear as marks to distinguish a shell's growth stage and estimate its age.

Juveniles, sub-adults and adults are, in fact, easily separable. Juveniles increase their size quickly. Due to this, barely one or two very interspaced rest-structures are visible in the 1.13 whorls (average extent of the activation zone in *O. mustelina*) surviving the internal skeletal absorption (which affects all the individuals, and not only the older ones). Sub-adults increase in size at a reduced speed. Thus, two or three rest-structures are observable. Finally, in the adults, which grow slowly, the rest-structures occupy a large part of the shell's cross-section (Figure 2B). As for estimating the shell's age, the rest-structures are not directly interpretable. How much time elapses between two growth phases? As the distance between successive rest-structures varies, and only those present in the non-reabsorbed teleoconch are detectable, is there any way to estimate their total number produced by the animal?

In the following paragraph, I will summarize the methodology and the results obtained for *O. mustelina*. Another question, however, requires an immediate answer: Why have the rest-structures escaped the investigations of other scholars? On the one hand, X-ray pictures, as those taken by Zeigler and Porreca, detect relevant density variations, which are far beyond those of the rest-structures. Low density also explains why the two authors misinterpreted the internal skeletal absorption. Vestiges of the early whorls are always present inside an Olive in the form of an extremely fragile veil (which usually breaks while preparing a cross-section). The ratio between the thickness of the veil and that of the teleoconch is relevant in juveniles, but becomes negligible in adults. Thus, the full veil appears in X-ray pictures of juveniles, but not in those of adults, giving way to the false impression that internal skeletal absorption only affects older shells. On the other hand, the cross-sections figured by Tursch and Greifeneder in

2001 come from juveniles, which had not yet gone through a rest phase. Apparently, the two authors did not like to waste large Olives. They sacrificed to science only the small and less appraisable specimens. Finally, Sterba could have described Olives' segmented lip area only by cutting an adult. Yet, he focused on the lip and the parietal callus, and neglected what lays in between.

REST-STRUCTURES AND SHELL AGE

Only statistics can transform the discovery of the rest-structures into a tool useful to estimate a shell's age. The sample prepared for analysis included 25 specimens of *O. mustelina* from the East China Sea, between 20.3 and 32.9 mm in length. Each specimen was cut perpendicular to the shell axis, along its maximum circumference. The cross-sections were ground, polished and digitally acquired. A few served to extrapolate the spiral profile of the activation zone, whose center marks the intersection of the shell axis with the cutting plane. Each section was then centered on a digital goniometer. Measurements included the angular positions of the inner and outer ends of the activation zone, and of the largest protein foil of each rest-structure.

The overall inspection of the cross-sections suggested that rest-structures form yearly. The shells of the sample displayed up to ten primary stops, pointing at an age of at least ten years, a figure matching the age of *Oliva oliva*, *Olivancillaria deashayesiana* and *Olivella biplicata* estimated by others using different methods. The same inspection also revealed that growth can be plain or troublesome: some specimens had single stops, others paired stops, and others very articulated rest-structures. Such a variety indicates that, depending on environmental conditions, besides a primary growth phase, one or more re-assessments had occurred. In any case, the final stop of a rest-structure was marked by a body-whorl bulge and a thick protein foil.

The purpose of the statistical analysis was to connect the data from the single cross-sections. Every specimen brings no more information than that present in its last 1.13 whorls. In order to extrapolate the whole story of an average shell, all the sections must concur to create the complete growth curve of the sample. A three-step procedure was used for this purpose:
1. Divide the sample in classes based upon the number of teleoconch whorls (specimens within the same class should have about the same age);
2. Average the angular distances between matching rest-structures within each class (specimens with the same age should develop in about the same way); 3. Merge and average the data from all the classes to obtain the complete growth curve (Figure 3).
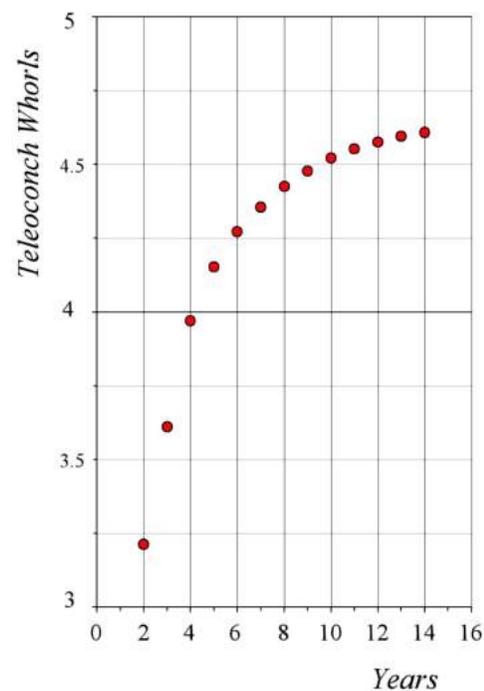
Figure 3. Statistic growth curve of *Oliva mustelina* Lamarck, 1811, resulting from a sample of specimens from East China Sea. The one year dot, extrapolated from the observed growth curve, should be placed around 2 teleoconch whorls.

The result's accordance with the growth curve for living beings devised by Ludwig von Bertalanffy (1901-1972) in 1938, confirms that rest-structures form on a yearly basis [cf. Arrighetti *et al.* 2012: 167]. It also makes apparent that, as rest-structures concentrate towards the lip, the information of the body whorl suffices to indicate the stage and age of a shell. If barely two well-interspaced rest-structures are present, the shell is a juvenile of no more than three years old (the curve grows quickly). Specimens displaying two or three nearer rest-structures are three to five year old sub-adults (the curve bends). Adult specimens have four or more rest-structures (the curve grows asymptotically). In general, if a specimen shows, let's say, seven rest-structures, as the statistical growth curve indicates that another three would have been present in the previous whorls, the shell is ten years old (plus/minus one year for the statistical error).

From a logical point of view, the growth curve only adapts to *O. mustelina* from the East China Sea. No relevant discrepancy emerges, however, from its application to the whole species and to its close relatives (*i.e.* species of the subgenus *Musteloliva* Petuch & Sargent, 1986). Caution suggests that, until specific analysis is performed, the growth curve only represents a coarse tool to estimate the age of other Olives.
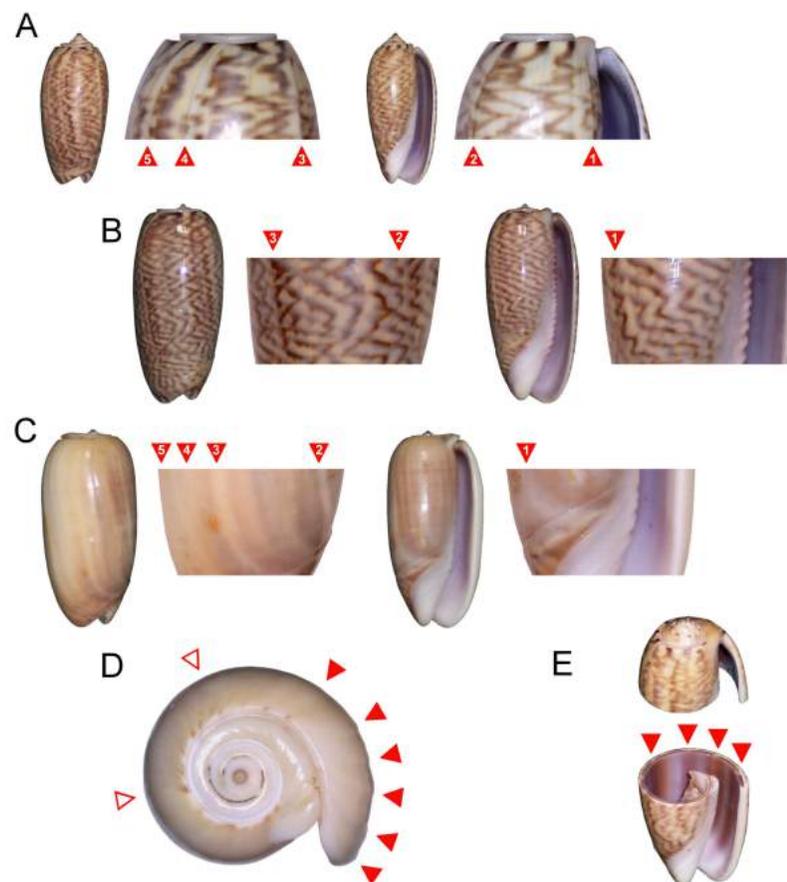
Figure 4. Clues for locating rest-structures and previous positions of the shell's lip: **A.** Protein foil's dark lines; **B.** Shell pattern discontinuities; **C.** Overall color discontinuities; **D.** Body whorl bulges; **E.** Color bands inside the aperture.

Obviously, such a tool would be almost useless (especially for collectors) if the rest-structures cannot be identified without cutting a specimen. However by comparing the cross-sections of *O. mustelina* with the external features of the shells, it became, apparent that this is not the case. Four clues — which may work jointly or individually — can help to locate and count rest-structures:

1. The primary stop of a rest-structure is marked by a thick protein foil. The foil appears on the outside of the body whorl as a longitudinal dark line (Figure 4A). In some cases, placing the shell in water — *i.e.* changing the refraction of light passing through the external glaze — emphasizes the protein lines.

2. When the animal restarts growth, the shell's pattern undergoes a discontinuity (Figure 4B). In un-patterned specimens, a color transition may occur (Figure 4C).

3. When the animal is close to rest, it enlarges the activation zone. As a first effect, a slight external longitudinal bulge marks any previous position of the shell's lip. A bulge is detectable by sight (especially by light reflection against the external gloss) and touch (Figure 4D).

4. As a second effect, the medium layer is pushed inwards at the expense of the internal layer. If the color of the activation zone, and the medium and internal layers are very different (as in *O. mustelina*), a longitudinal color band may appear inside the aperture (Figure 4E).

The last clue is, of course, the less suitable. Only a fraction of the body whorl is visible inside the aperture. Moreover, very close rest-structures may produce coalescing color bands. As for the other three clues — especially when searched in species distant from *O. mustelina* — problems may emerge with extremely smooth shells or in the presence of heavily pigmented external glazes. Finally, in the very adult and gerontic specimens, the rest-structures are so tight that their thorough count becomes almost impossible.

TAXONOMIC CONSEQUENCES

In defiance of the old criterion to identify juveniles, sub-adults and adults, the aspect of the Olives' lip allows for various interpretations. A sharp lip may denote a growing juvenile, sub-adult or adult. A moderately thick round lip may indicate a juvenile or a sub-adult during rest, or an adult close to rest. Finally, a very thick round lip may belong to a sub-adult or an adult during rest. In order to distinguish the correct case, it is indispensable to estimate the specimen's age by the number of rest-structures visible on the body whorl. If this is not done, a large adult with a wedged lip can be mistaken as a juvenile giant or, vice-versa, a small sub-adult with a round lip as an adult dwarf. Going from this to serious taxonomic consequences is a short step.

In 2005, Sterba described a new species based upon two commercial lots of eleven specimens from Kuantan, on the east coast of the Malay peninsula, and of four specimens with no locality data. The lots included six "juveniles" and nine "adults". The holotype of the new species, *Oliva virgata* Sterba, 2005, belongs to the first lot. It is 22.2 mm long and is deposited at the Museum Haus der Natur-Cismar, in Grömitz, Germany (HNC 64409), together with paratype 1 of 19.6 mm (HNC 64410), and paratype 7 of 20.1 mm (HNC 64412). Other eight paratypes are in Sterba's collection in Markkleeberg, Germany. The species has about 3.5 teleoconch whorls and, on an ivory or light ocher background, displays a pattern of red-brown zigzag stripes, hence its name (Latin *virgata* = striped). The inside of the aperture is violet [Sterba 2005: 75].

Comparisons with other species within the 15-25 mm length class and with similar patterns —

Oliva rufofulgurata Schepman, 1904; *Oliva panniculata* f. *williamsi* Melvill & Standen, 1897; *Oliva brettinghami* Bridgman, 1909; and *Oliva faba* Marrat, 1867 (striped form) — revealed the soundness of the new taxon. Even by including the 25-35 mm class, where only *Oliva baileyi* f. *lenhilli* Petuch & Sargent, 1986, displays a similar pattern, the result remains unchanged. At least one detail — the color of the aperture, the color or size of the protoconch, the length of the zigzag stripes, the plications on the parietal wall, the spire callus, etc. — makes *O. virgata* different from any other species [Ibid.: 77].

The comparisons did not include *O. mustelina*. And for what reason should it be included? On a light ocher background, this larger species displays a net of overlapped zigzags. The pattern is relatively constant all over the distribution range: Malaysia, Indonesia, South and East China Sea, Philippines, Japan [Zeigler & Porreca 1969: 74; Petuch & Sargent 1986: 30 and 41, fig. 19; Tursch & Greifeneder 2001: 372; Sterba 2004: 56; Hunon, Hoarau & Robin 2009: 131]. The only exception is the uniformly beige *O. mustelina* f. *lanberti* Bert, 1984 (with "n", not "m"), from South-West Taiwan [Bert 1984: 7] (Figure 7B).

My search for *O. virgata* initially brought in the picture of a specimen from Klebang, on the west coast of the Malay peninsula, about 250 km to the north of Singapore, originally identified as *O. mustelina*. The first tangible lot came from the Changi Coast of Singapore, about 300 km to the south of the type locality. It included specimens with sharp and round lips between 22.0 and 32.4 mm. Interestingly enough, while the small shells matched the holotype [ill. Sterba 2005: 76, pl. 5, fig. 1], the
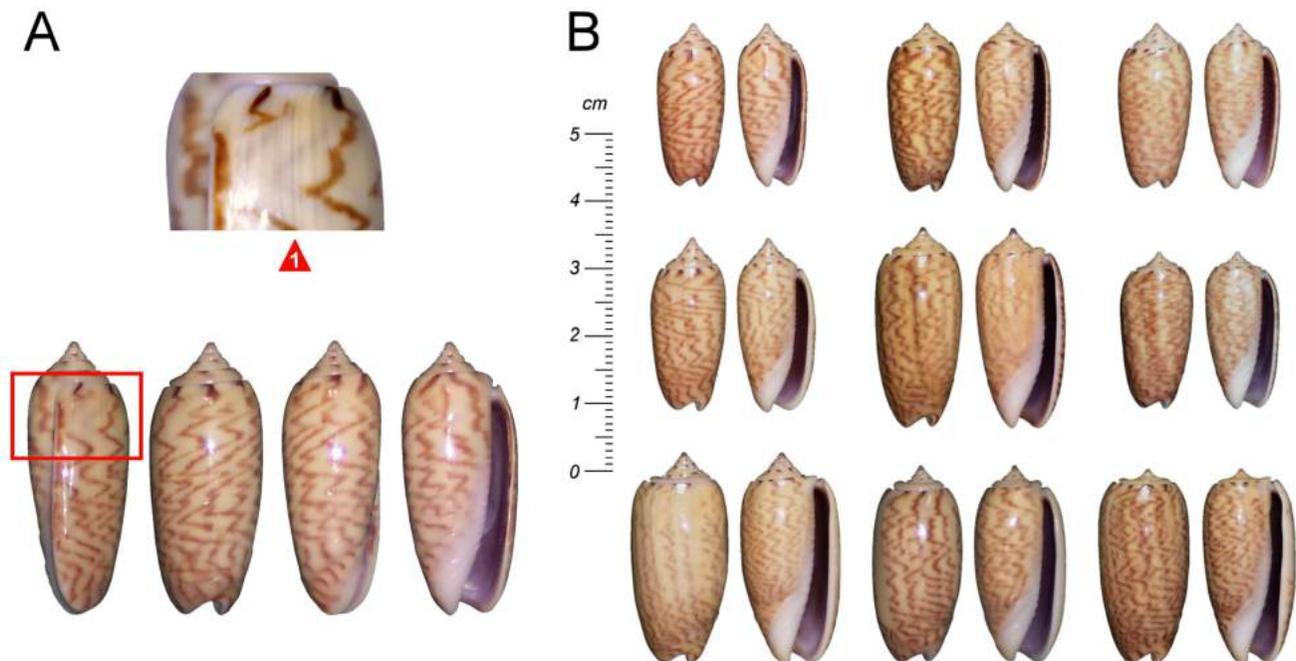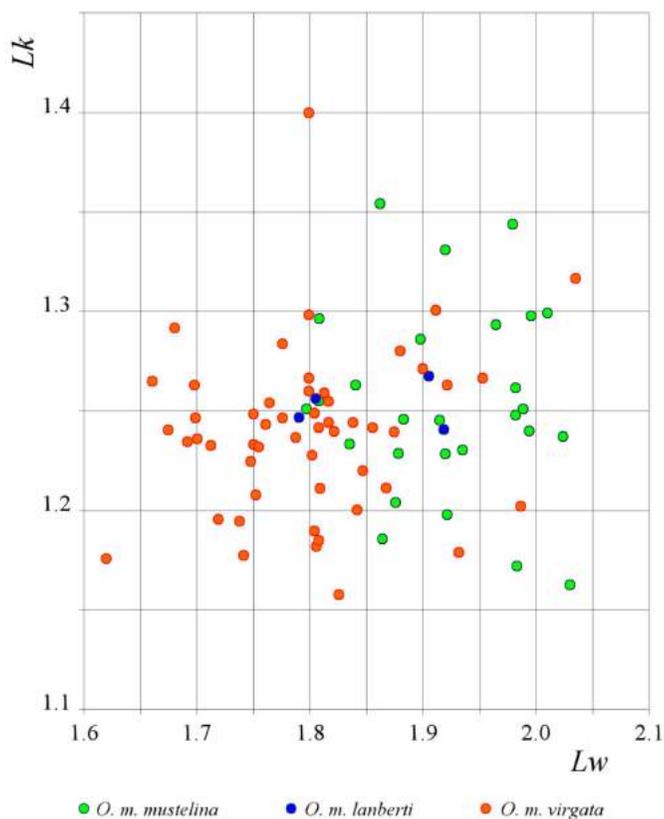

Figure 5. Comparison between *Oliva virgata* Sterba, 2005 and *Oliva mustelina* Lamarck, 1811: **A.** Location of rest-structures in a typical *O. virgata*; **B.** Intergrades from *O. virgata* (upper left) to *O. mustelina* (bottom right). All specimens from Changi Coast, Singapore.

large ones offered an assortment of intergrades between *O. virgata* and *O. mustelina*; a situation emphasized by a second lot of shells between 28.3 and 33.2 mm from the same locality. The suspicion that the two species could be interconnected was confirmed by a third lot of specimens between 26.8 and 32.9 mm, from East Coast Park, Singapore. But what was the level of the interconnection?

The discovery of rest-structures provides part of the answer. By examining the holotype of *O. virgata* and other identical specimens, it is easy

to realize that only one or two protein lines appear on their last whorl (Figure 5A). Notwithstanding their round lip, these shells are juveniles no more than four year old, gathered during rest (hence their "adult" look according to the old misleading growth model). As the animal develops, the zigzag stripes overlap and tend to produce the netted pattern of *O. mustelina*. Adult shells more than six year old have the same light ocher background, the same violet aperture, the same plication structure of the parietal wall, and the same small and dark brown protoconch of *O. mustelina* (Figure 5B).

If no doubt remains that *O. virgata* and *O. mustelina* are the same species, the first being based upon juveniles of the second, the answer about their interconnection is still incomplete. The striped pattern of the Malaysian non-adults does not occur with the same frequency all over the distribution range of *O. mustelina*. Also the relatively exerted spire and tapered shape of many individuals from Klebang, Singapore and also New Guinea is less usual elsewhere. The geographical limitation, corresponding to the west and southern edge of the range of *O. mustelina*, suggests that, more than a mere form, *O. virgata* represents a Malaysian and Indonesian subspecies. This taxonomic status is supported by morphometric analysis (*see* Table 1 and Figure 6).

A similar case involves *Oliva mucronata* Marrat, 1871, originally described as "Allied to *O. mustelina*, but distinguished from that species by its fine and close columellar plaits. The texture and pattern are also different" [Marrat 1870-1871: 22, no. 115; pl. XVII, figs. 274, 275]. Over the time, Marrat's description and figures have been variously interpreted. For Zeigler and Porreca *O. mucronata* was a synonym of *Oliva athenia* Duclos, 1840 [Zeigler & Porreca 1969: 65]. Edward J. Petuch and Dennis M. Sargent considered *O.*

Figure 6. Plot graph of the growth factors *Lw* and *Lk* (*Lk* = Distal growth factor; *Lw* = Ab-axial growth factor) for *Oliva mustelina mustelina* Lamarck, 1811 (green dots), *O. mustelina mustelina* f. *lanberti* Bert, 1984 (violet dots), and *O. mustelina* ssp. *virgata* Sterba, 2015 (orange dots).

mucronata a valid species, but also a homonym of *Oliva mucronata* d'Orbigny, 1850. They created the new name *Oliva mucronalis* Petuch & Sargent, 1986, which they applied to a specimen of *Oliva dactyliola* Duclos, 1840 [Petuch & Sargent 1986: 79 and pl. 7, figs. 3, 4]. Sally Diana Kaicher accepted both the validity of the species and the new name, which she exemplified by one of Marrat's two syntypes at the Merseyside County Museum — today's World Museum — of Liverpool [Kaicher 1988: no. 5256]. Tursch and Greifeneder also opted for the species' validity. They noted, however, that its renaming was unjustified, because Alcide d'Orbigny's species is not an *Oliva* [Tursch & Greifeneder 2001: 454]. In fact, it is the Eocene fossil *Pseudolivella mucronata* (d'Orbigny, 1850). The two authors illustrated Marrat's taxon with three specimens from Hansa Bay, Papua-New Guinea [Ibid.: 348-349; col. pl. 15, figs. 7-9], which hardly resemble the selected lectotype [ill. Ibid.: 526-527, pl. T-29, fig. 1]. Jorgen Hylleberg and Richard N. Kilburn listed *O. mucronata* from Nha-Trang, Vietnam, as different from both *O. mustelina* and *O. athenia*. Regrettably, they did not accompany the corresponding entries in their check-list of Vietnamese mollusks with figures [Hylleberg & Kilburn 2003: 92-93]. A puzzled

Sterba considered the species both a synonym of *O. athenia* [Sterba 2004: 90], perhaps by referring to Marrat's second syntype [ill. Tursch & Greifeneder 2001: 524-525, pl. T-28, fig. 8], and a valid species [Sterba 2004: 153]. Finally Christian Hunon, André Hoarau and Alain Robin claimed that *O. mucronata* is a dwarf form of *O. mustelina* from Vietnam [Hunon, Hoarau & Robin 2009: 130-131], which they illustrated with a juvenile of *O. m. mustelina*.

The already mentioned lectotype of *O. mucronata* is 16.6 mm high. Its last whorl shows only two major protein lines which, in addition to the thickened lip, suggests that the shell is at maximum of four years old. It is a juvenile or sub-adult gathered during rest. An almost identical find from Nha-Trang, Vietnam, fully adult and 30.8 mm high (Figure 7C) confirms the recent claim that *O. mucronata* is an *O. mustelina*. It is, however, not a dwarf form. The shell is characterized by an overall shape close to the northern typical subspecies *O. m. mustelina* (Figure 7A), and a pattern close to the southern subspecies *O. m. virgata* (Figure 7D). Until a suitable number of specimens is available for morphometric analysis, caution suggests to provisionally consider *O. mucronata* a color form of *O. m. mustelina*.

	Nw	Tw (max)	W/H (%)	*Lk*	*Lw*	Plicae (means)
O. m. mustelina	ca. 3.25	5.0	0.52 ± 0.02	1.253 ± 0.048	1.922 ± 0.071	10.5 / 2.4 / 3.4
O. m. lanberti	n.a.	4.7	0.53 ± 0.02	1.253 ± 0.012	1.855 ± 0.066	11.5 / 2.5 / 5.5
O. m. virgata	ca. 3.25	4.8	0.49 ± 0.02	1.240 ± 0.042	1.799 ± 0.084	11.5 / 2.8 / 3.6

Table 1. Data comparison between *Oliva mustelina mustelina* Lamarck, 1811, *O. mustelina mustelina* f. *lanberti* Bert, 1984, and *O. mustelina* ssp. *virgata* Sterba, 2005 (Nw = Nuclear whorls; Tw = Teleoconch whorls; W/H = Width/High ratio; *Lk* = Distal growth factor; *Lw* = Ab-axial growth factor).
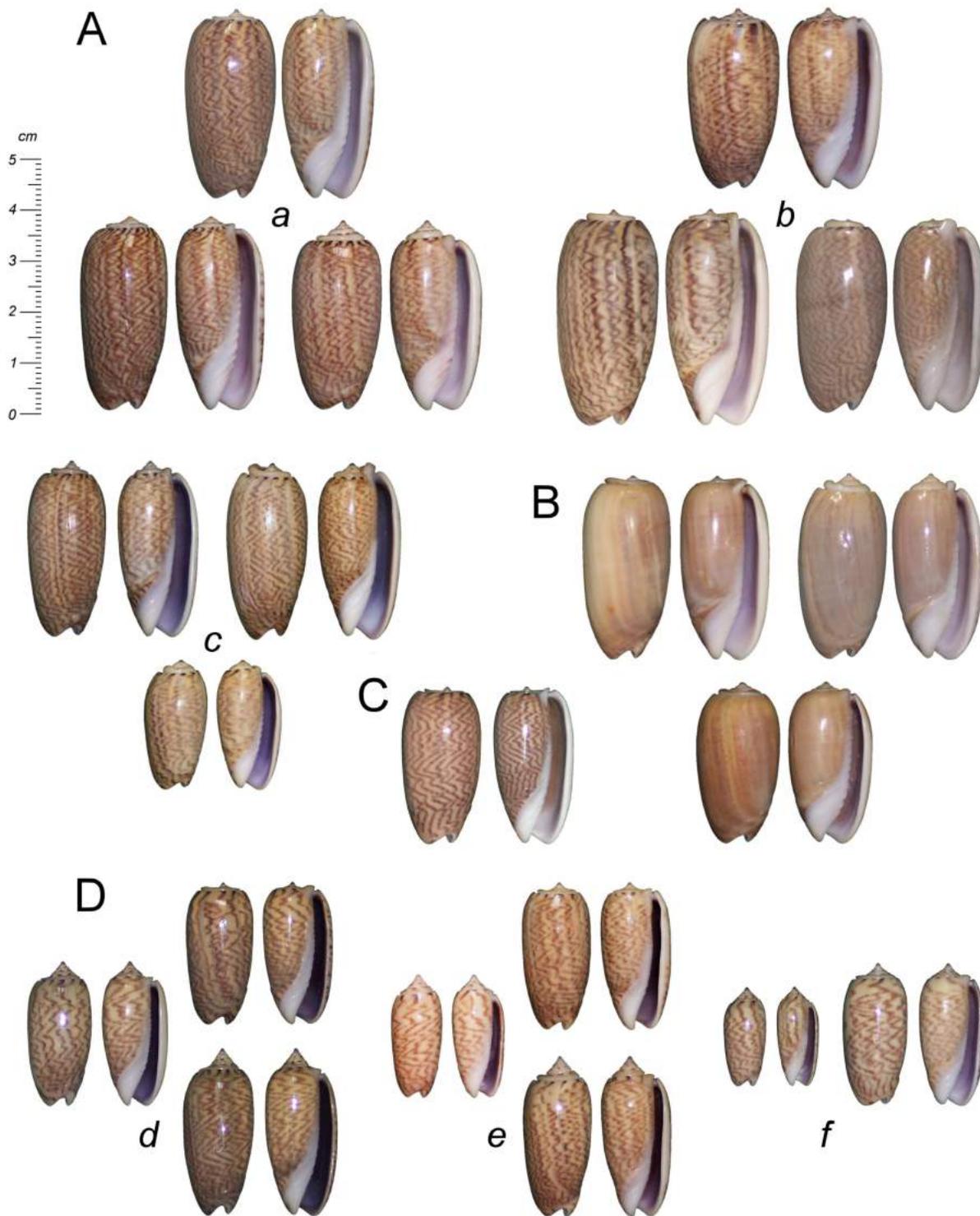
Figure 7. Taxonomic reassessment: **A**. *Oliva mustelina mustelina* Lamarck, 1811 from: *a*. Japan, *b*. Taiwan, *c*. East China Sea; **B**. *Oliva mustelina mustelina* f. *lanberti* Bert, 1984, Taiwan; **C**. *Oliva mustelina mustelina* f. *mucronata* Marrat, 1871, Nha-Trang, Vietnam; **D**. *Oliva mustelina* ssp. *virgata* Sterba, 2015: *d*. East Coast Park, Singapore, *e*. Changi Coast, Singapore (juvenile and adults), *f*. Milne Bay, New Guinea (juvenile and adult).

CONCLUSIONS

For a special mindset, while evaluating a shell, collectors are far from considering that what they have at hand represents an instant in the life of a living being. The idea that the shell would have been different if gathered a few years (or even a few weeks) earlier or later, only emerges for those gastropods undergoing remarkable age-related changes. If differences are negligible, or if the shell's growth stage is determined upon wrong prejudices, the strong desire to create a new name easily prevails. As a result, a non-adult specimen can be perceived as the representative of a new species, rather than as a young member of the already described species to which it belongs.

The discovery of rest-structures and their use to estimate the age of an Olive, will hopefully help to relocate a few problematic taxa and avoid any further creation of ephemeral species. A name should only be given if the type material has been previously tested for the presence of real adults. In fact, unchecked material could be taxonomically "dangerous". Not only could it be the result of a pre-selection made by fishermen or dealers, but there is no evidence that a non-adult Olive would look the same (except for the size) if it would have lived another few years. Rather, evidence shows that non-adults may be very different from adults, as in the case of *O. mustelina*.

The discovery of rest-structures also has relevant ecological implications. When before living specimens, responsible collectors should evaluate whether they are adults that have already had the possibility to mate and multiply, or juveniles and sub-adults, which must be given the opportunity to reach maturity. While no objective criterion is available to distinguish an Olive's growth stage, the answer rests upon the collector's personal skill: experience could inspire collectors to pick up only a fraction of the findings or the larger ones. But once a reliable criterion is available to estimate, the age and growth stage of a specimen, no excuse can justify indiscriminate collecting. Olives' longevity, which averages twelve years for a medium size species (and likely longer for bigger species) should inspire selection of only very mature shells.

Unfortunately, no wise course had been followed in the last decades. The sad behavior of gathering everything is, in fact, a testament to the progressive disappearance of large specimens. If Olives have to survive an intense "massive mortality" from natural predators when they are juveniles [Tursch, Ouin & Bouillon 1995: 35-36], and a human spoliation at any age, only very few individuals will be able to reach 15 years of age. If you are an Olive shell collector, just ask yourself: How many *Oliva bulbosa* (Röding, 1798) larger than 50 mm do I have? Very likely, the answer will be: None. Yet, such large specimens from unspoiled seas were rather frequent in the nineteenth century collections.

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Interesting find:

Limaria hemphilli (Hertlein & Strong, 1946) photographed by Club member Robyn Waayers in Mission Bay, San Diego.