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Overview of the **Tonnidae** (Mollusca: Gastropoda) in Chinese waters

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Abstract: An overview is given of the species of **Tonnidae** which occur along Chinese coasts, from the South China Sea at the border with Vietnam in the west, to the eastern part of the East China Sea in the east, and including Taiwanese waters. The most common synonyms, distribution in general and specifically in Chinese waters, and notes on taxonomy, biology and background information are listed.

Introduction: A specific assessment of the family **Tonnidae** in Chinese waters was published by Zhang Suping & Ma Xiutong (2004), including most species which occur in Chinese waters, and including a number of drawings. Vos (2005) examined the true identity of *Tonna chinensis* (Dillwyn, 1817), duly allocating a neotype for the latter, in a period when much confusion existed between that species and *Tonna cumingii* (Hanley in Reeve, 1849). Vos (2007) revised the entire family on a taxonomical level and published the global distribution per species. Ever since, additional species have been recorded from Chinese waters and additional information has become available through observations in the natural habitat. The purpose of the present article is as such to give an overview of all species currently known to occur in Chinese waters, provide insight in their behaviour, and to clarify on some historically incorrect taxonomical issues.

Versioning: The present article was translated into Chinese for publication purposes. For scientific purposes, the present original English version is considered master-version as the translation could not be done under the responsibility of the present author.

1. Taxonomical aspects:

Bouchet & Rocroi (2005) listed **Cassidae** as a synonym of **Tonnidae** Suter, 1913 (1825), following Riedel (1995). The two families are maintained separate within the World Register of Marine Species (WoRMS) following Beu (2008: 272) (fide Gofas, S. (2012) *Tonnidae*. Accessed through: World Register of Marine Species at <http://www.marinespecies.org/aphia.php?p=taxdetails&id=23129> on 2012-09-18)

The present author (also see Vos, 2007:7) has opted to follow the vision of Beu (2008) and as such to maintain **Cassidae** and **Tonnidae** as separate families.

2. Biological aspects

2.1 Gender (Plate 1)

Genders in **Tonnidae** are separate and there is no obvious sexual dimorphism in shell characteristics, with the exception of the lower part of the lip being extended below the fasciole in some specimens, indicating a more spherical build of the shell in the preceding growth phase. Those specimens where this is the case, appear to have been females which had eggs stored in that area (or had recently ejected the egg mass, or were constructing the shell with that purpose) at the time of capture. Traces of this egg mass can sometimes be observed inside the aperture. Whether or not the same more spherical build of the shell is continued after the ejection of the egg mass, and only continued at a later growth phase - with one or more "normal" growth stages in between - remains uncertain and has at present not sufficiently been examined nor observed.

Male specimens of *Tonna luteostoma* (Küster, 1857) have been observed to be smaller than female specimens, yet the actual act of reproduction has as yet not been observed (Takashige, H. and Masuko, H. (both Shizuoka, Japan); pers. comm. 2011).

2.2 Reproduction and larval stage

Fertilization is internal, and the egg mass -a gelatinous ribbon- can contain up to 660000 eggs. The larvae are planktotrophic, and the pelagic stage can last as long as one year. During that stage **Tonnidae** have an operculum, which is disposed of when they settle. The consequence of this long pelagic stage is that they are in general widely distributed over a large area. Survival within the area where they settle will depend on food availability and habitat conditions.

2.3 Feeding (Plate 2)

In the adult stage, **Tonnidae** are vicious, nocturnal hunters, solely feeding on Holothuria. During the day, they hide in the sand or gravel and come out at night to

hunt for food. Beesley *et al.* (1998), Morton (1991) and Vos (2007) already reported that **Tonnidae** solely feed on Holothuria and suggested that a relation appears to exist between specific species of **Tonnidae** and specific species of Holothuria.

Tonnidae have a large foot, enabling them to develop a relatively high speed whilst moving over the sand in search for food. When fully extended during hunting, the size of the foot is approximately 3 times the length and 3 times the width of the shell. Their large proboscis is placed on the prey, which is first paralysed by a 3-5% sulphuric acid and then hauled in through two proportionally large jaws. Inside the proboscis, the prey is passed by the proportionally large radula, partially ripping it apart and digesting it. A second digestion takes place inside the stomach.

2.4 Growth of the shell

Like **Bursidae**, **Ranellidae**, **Cassidae**, **Muricidae**, etc ..., **Tonnidae** grow their shells episodically - that is, a brief period of growth produces about half to two thirds of a whorl, followed by a period of rest during which the thickened lip is developed. During these "rest" periods, females usually lay their eggs. When a next period of growth is started, the thickened outer lip is dissolved (as in most **Cassidae** and all **Tonnidae**). Sexual maturity (adulthood) is independent of growth pauses and starts at a relatively small size. Consequently, presence or absence of a thickened outer lip is not related to adulthood.

"Dwarf" specimens regularly occur in most species of **Tonnidae** as a result of habitat conditions and availability of (preferred) food sources.

2.5 Identification

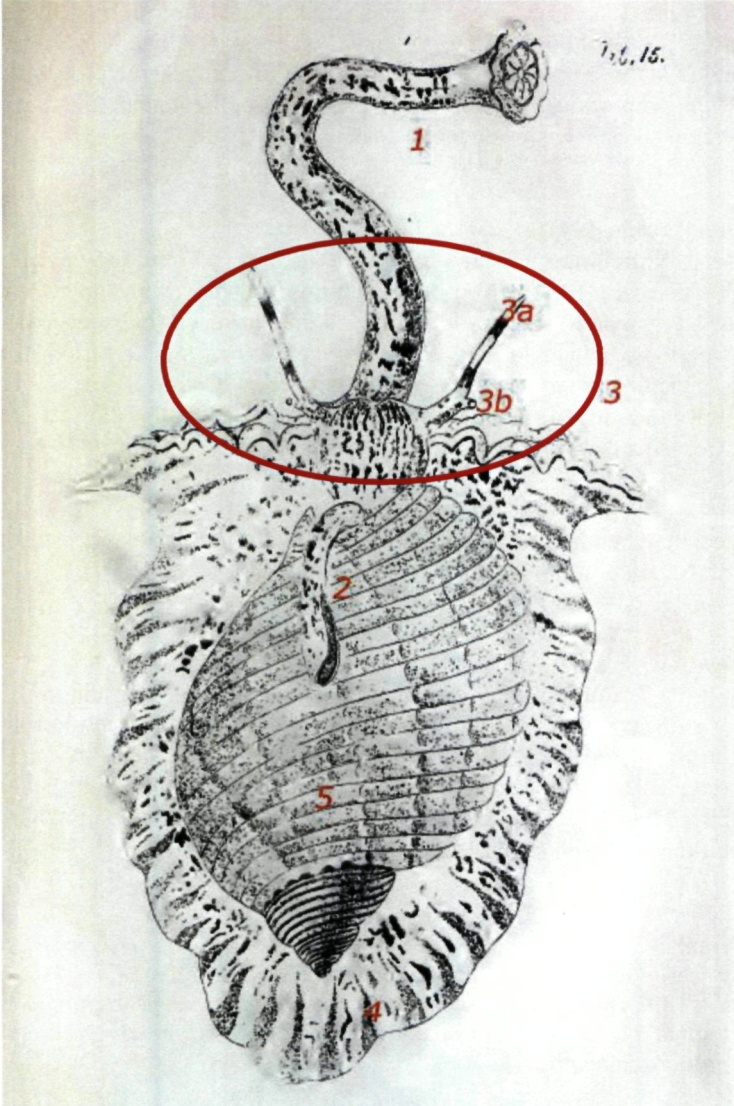
When identifying **Tonnidae**, caution should be issued as to the moment in its life cycle the animal was in (growth or rest) at the point of capture, the specific food sources and the habitat it was taken in. Many synonyms have been described throughout history which illustrate lack of consideration of these elements, especially with species which - in a rest phase- have an elaborate outer lip, which are likely to remain "dwarf" due to habitat conditions or which have a high degree of variation.

2.6 The animal

One of the early drawings of the animal of *Tonna* Brünnich, 1771 and *Malea* Valenciennes, 1832 was published by Maria Emma Gray in 1842 (reprinted 1859), and shows the animal *Tonna perdis* (Linnaeus, 1758) rather accurately yet maybe with a slightly disproportionate proboscis.

Key features of the animal (to which names are given in science):

1. large proboscis with which the prey is hauled in,
2. siphon,
3. broad head with wide spread cephalic tentacles (3a) and eyes (3b),
4. large, broad foot (here not fully extended),
5. shell.



(Copied from Gray, M.-E. (1859, Pl. 15))



Tonna canaliculata (Linnaeus, 1758).

Broad head and widely spread cephalic tentacles, with the eyes visible just before the basis of the cephalic tentacles. Above the right cephalic tentacle, the siphon is visible.

(Photograph courtesy of Hakuei Masuko (Japan))

The shells of **Tonnidae** are most easily distinguished when 4 major characteristics are taken into account, each time with a degree of variation:

- general shape of the last whorl (taking apex height variation in some species into consideration)
- spiral sculpture (main distinguishing factor),
- lip finalisation after a growth phase (second most important distinguishing factor, with specific attention to the growth / rest phase at the time of capture),
- shape of the twisted canal.

3. Systematic of species occurring in Chinese waters

Class: Gastropoda Cuvier, 1795

Subclass: Caenogastropoda Cox, 1960

Order: Littorinimorpha Golikov & Starobogatov, 1975

Superfamily: Tonnoidea Suter, 1913 (1825)

Family: Tonnidae Suter, 1913 (1825)

Genus: *Eudolium* Dall, 1889(nom. nov. pro *Doliopsis* Monterosato, 1872 (non Vogt, 1852, non Conrad, 1865))Type species: *Dolium crosseanum* di Monterosato, 1869, (by monotypy)

Only two recent species of *Eudolium* are known to date, and both are circumtropical. Their shape reminds of *Galeodea* and *Oocorys* in Cassidae, indicating a close relation to **Cassidae**. Both live at depths below 100m, and are in Chinese waters usually trawled live between 150 and 450m.

***Eudolium crosseanum* (di Monterosato, 1869)**

(Plate 3, Figs 1a-d)

Synonyms include (a.o.):*Dolium crosseanum* di Monterosato, 1869 (original description)*Eudolium pyriforme* (G. B. Sowerby III, 1914)*Eudolium thompsoni* McGinty, 1955

Distribution: Circumtropical. In Chinese waters known from north-west Taiwan (Zhang & Ma, 2004:80; listed as *Eudolium pyriforme* (Sowerby, 1914)); south-west Taiwan (Coll. author) and East China Sea where it has been trawled at depths of 180 to 200m.

Remarks: For many years -and still often today-, this species has erroneously been referred to as *Eudolium pyriforme* (Sowerby III, 1914). Already in 1977, Piani discussed the holotypes of the two taxa, but this information never seems to have reached the general public. Vos (2007: 23-25) examined both holotypes and concluded identical to Piani (1977). The wider distribution of that book makes that correct identifications are slowly appearing in popular magazines and on popular websites.

***Eudolium bairdii* (Verrill & Smith in Verrill, 1881)**

(Plate 3, Figs 2a-d)

Synonyms include (a.o.):*Dolium bairdii* Verrill & Smith in Verrill, 1881 (original description)*Eudolium crosseanum* var. *solidior* Dautzenberg & Fischer, 1906*Eudolium lineatum* (Schepman, 1909)*Eudolium inflatum* Kuroda & Habe, 1952*Eudolium kuroharai* Azuma, 1960

Distribution: Circumtropical. In the current context known from north-west Taiwan (Zhang & Ma, 2004:80); north-east and south-west Taiwan and East China Sea (Coll. author) where it has been trawled at a depth of 200m.

Remarks: Variable species where colour and smoothness of the primary cords is concerned. Vos (2007:21) examined the spiral sculpture (from entirely smooth to very nodulose) and colour of the primary cords (from white to dark brown) in relation to the locality, and concluded that there were no obvious relations between the three elements. This species is therefore considered highly variable - a feature which has led to descriptions of synonyms in the past.

Genus: *Malea* Valenciennes, 1832

Type species: *Malea latilabris* Valenciennes, 1832 (= *Cassis ringens* Swainson, 1822)

Only two recent species of *Malea* are currently known, one of which occurs along western Mexican shores to Peru and the Galapagos, and the other -here concerned- occurs throughout the Indo-Pacific. Both members of this genus are shallow water species.

Malea pomum (Linnaeus, 1758)
(Plate 3, Figs 3a-b)

Synonyms include (a.o.):

Buccinum pomum Linnaeus, 1758 (original description)

Malea pomum macgregoryi Iredale, 1931

Malea noronhensis Kempf & Matthews, 1969

Distribution: Widely spread in the Indo-Pacific and Red Sea, and off the northern Brazilian coast and Guadeloupe in the western Atlantic. Recorded from the South China Sea and Taiwan (Zhang & Ma, 2004:83; Coll. author).

Remarks: The variation of colour and pattern appears to be related to the habitat, and is of such extent, that it is an ideal species for a colour variation study.

Genus: *Tonna* Brünnich, 1771

Type species: *Buccinum galea* Linnaeus, 1758
(by subsequent designation Suter, 1913: 314)

So far, 11 species of *Tonna* have been recorded from Chinese waters, which is excluding two species which have been reported from there, but of which the exact locality is doubted. Most members of this genus live on sand flats at depths from 30 to 50m. A few species are only known from deeper waters, and a few mainly inhabit shallow water.

Vos (2007) grouped the species of *Tonna* in accordance with the historical taxonomical confusion, thus synoptically treating species which have been -and still are- mistaken for one another. This methodology was copied by www.gastropods.com in a way that it could potentially insinuate a subgeneric classification. However, such a subgeneric classification would be of no use, as there are -at present- no distinguishing parameters -neither genetic nor morphological- nor necessity to proceed in that direction.

Species with reliable records of occurrence

Tonna allium (Dillwyn, 1817)
(Plate 4, Figs 1a-e)

Synonyms include (a.o.):

Buccinum allium Dillwyn, 1817 (original description)

Dolium costatum Menke, 1828

Tonna hardyi Bozzetti & Ferrario, 2005

Distribution: Widely spread throughout the Indo-Pacific where it inhabits intertidal flats, yet it is also recorded from depths down to 50m. In the current context recorded from the South China Sea eastwards along the Chinese coasts and south-west Taiwan (Zhang & Ma, 2004:69) and from shallow water in the South China Sea to north-east Taiwan (Coll. author).

Remarks: This species appears very sensitive to habitat conditions and food availability, as it is highly variable in size, base colour and colour of the primary cords, and dwarf specimens regularly occur - especially in the southern Indian Ocean and South African waters.

Tonna dolium (Linnaeus, 1758)
(Plate 4, Figs 2a-b)

Synonyms include (a.o.):

Buccinum dolium Linnaeus, 1758 (original description)

Dolium maculatum Lamarck, 1822

Distribution: This species is not common, and occurs from the Philippines to South Africa, and is only rarely reported from Australia and northernmost New Zealand. It inhabits waters from 30m to over 100m deep. Its occurrence in Chinese waters is uncertain, and most records of "*Tonna dolium*" in Chinese waters turn out to be specimens of *Tonna lischkeana* (Küster, 1758) at examination. It is listed here mainly

in order to illustrate the difference between these two species. Zhang & Ma (2004:68) listed this species yet added *Tonna lischkeana* (Küster, 1857) to its synonymy, and added a drawing of that species rather than *Tonna dolium* (Linnaeus, 1758). It is as such considered that the distribution listed in that publication concerns *T. lischkeana* only.

Remarks: This species has historically been confused a lot (amongst other) with *T. lischkeana*, yet is easily distinguished from that species by the small amount of spiral cords and strong twist in the fasciole. The spiral cords of *T. lischkeana* are finer and more elevated than the broad and low primary cords in *T. dolium*. Whilst the spiral sculpture of *T. lischkeana* is very stable and hardly shows any variation, the spiral sculpture of *T. dolium* is highly variable, and such as of the young stage.

In historical literature, this species is quite often referred to as *Tonna maculata* (Lamarck, 1822), which is a junior synonym of *T. dolium*. When Lamarck introduced the genus *Dolium* for the large, spherical shells which had been classified under *Buccinum* by Linnaeus, he seems to have opted to avoid tautonomy, and as such renamed Linnaeus' *Buccinum dolium* as *Dolium maculatum*. However, prior to Lamarck's genus, Brünnich had already isolated the large spherical shells in a genus called *Tonna*. As Linnaeus' species name is a valid and available name, just like the genus name introduced by Brünnich, the correct name for this species becomes *Tonna dolium* (Linnaeus, 1758).

Tonna lischkeana (Küster, 1857)
(Plate 4, Figs 3a-c)

Synonyms include (a.o.):

- Dolium lischkeanum* Küster, 1857 (original description)
- Buccinum dolium* "Linnaeus" in Bruguière, 1789 (junior homonym)
- ? *Dolium marginatum* Philippi, 1845
- Dolium reevei* Hanley, 1860

Distribution: This species lives offshore, but has also been brought up with crab traps from 150m and deeper. It lives widely spread throughout the Indo-Pacific, from South Africa to Japan eastwards, and southwards to northern New Zealand including Hawaii. Recorded from South China Sea and off Hong Kong to East China Sea and around Taiwan (Coll. auth.), mostly from 10 to 20m deep.

Remarks: This species is commonly confused with *Tonna dolium* (Linnaeus, 1758) yet is easily distinguishable by the straighter canal and dense spiral sculpture of *T. lischkeana* as opposed to the few spiral cords and strongly twisted canal of *T. dolium* (also see previous species listed).

Some authors have used the name *Tonna marginata* (Philippi, 1845) for this species, yet it is uncertain what this name represents as the original description and references of Philippi are not clear and leave much room for interpretation. As the type material (supposed to be preserved in the Natural History Museum in Santiago, Chile) is currently unavailable for research, the name *T. marginata* is currently considered nomen dubium until the type material is available for examination. (also see Vos, 2007: 39).

Tonna tessellata (Lamarck, 1816)
(Plate 4, Figs 4a-b)

Synonyms include (a.o.):

Dolium tessellatum Lamarck, 1816 (original description)

Dolium fimbriatum G. B. Sowerby I, 1825

Dolium minjac Deshayes, 1844

Dolium fimbriatum var. *parvulum* Tapparone-Canefri, 1878

Distribution: Widely spread in the Indo-Pacific, from South Africa across the Indian Ocean to the Pacific; north to Honshu, Japan, and southwards to western Australia and northern Queensland. Regularly found in the Philippines, yet less common elsewhere.

This species was not reported from Chinese waters by Zhang & Ma (2004). A few specimens from northern Taiwan are present in the collection of the present author.

Remarks: Along with the three aforementioned species, this species has been confused with them many times throughout history. No type was found during research (Vos, 2007: 48) and many authors have tried to refer to the syntype of *Dolium minjac* Deshayes, 1844 (= Le Minjac of Adanson (1757)) which is a very worn specimen with a very immature lip. The drawing of Lamarck (1816, pl. 403), however, leaves no doubt as to the identity of this species. Vos (2007: 48) designated a neotype which resembles the drawing of Lamarck in all features, including the slightly immature lip and lack of callus on the twisted canal.

Tonna canaliculata (Linnaeus, 1758)
(Plate 5, Figs 1a-c)

Synonyms include (a.o.):

Bulla canaliculata Linnaeus, 1758 (original description)

Buccinum olearium "Linnaeus" in Bruguière, 1789 (junior homonym)

Tonna cepa (Röding, 1798)

Tonna planicostata Dodge, 1956 (unnecessary replacement name for *Buccinum olearium* "Bruguière")

Distribution: Widespread across the Indo-Pacific; From South Africa east to Japan, and southwards to Australia, and including Hawaii, Guam and New Caledonia. Also present along the coasts of eastern Africa and in the Red Sea.

Reported from Hainan, South China Sea and south-west Taiwan by Zhang & Ma (2004:80). Also present from South China Sea (from off Nha Trang, Vietnam) in the collection of the present author.

Remarks: Linnaeus initially named this species *Bulla canaliculata* as such distinguishing it from the other species of **Tonnidae** which he listed in the genus *Buccinum* presumably because of the very distinctive canal along the suture, its very thin shell and spherical shape.

Tonna sulcosa (Born, 1778)
(Plate 5, Figs 2a-d)

Synonyms include (a.o.):

Buccinum sulcosum Born, 1778 (original description)

Dolium fasciatum "Martini" in Bruguière, 1789

Tonna fasciata (Bruguière, 1789) (unnecessary recombination of synonym)

Dolium varicosum Preston, 1910

Distribution: Widely spread out over the Indo-Pacific, from South Africa east to the western part of the Pacific, southwards to eastern Australia, and northwards to Honshu, Japan.

Recorded by Zhang & Ma (2004:74) from Hainan and the South China Sea along the Chinese coasts to as far north-east as Fujian, and from south-west Taiwan. Also collected from north-east Taiwan in shallow water (10-20m); north of Taiwan in deeper water (80m) and from shallow water off Wailingding Dao, Guangdong area, South China Sea in collection of the present author.

Remarks: The phased growth method of **Tonnidae** is of such particularity, that the lip -which was elaborated at the end of a "growth" phase- is dissolved and the growth of the shell is continued. However, it can happen that the lip is not dissolved, possibly due to a calamity (predator attack, dredging, ...) prior to the subsequent growth phase. In such case, the lip is sometimes not dissolved and the shell is continued after the previous lip. In most species of **Tonnidae**, this mis-growth is hardly visible, yet in *Tonna sulcosa* (Born, 1778), as a consequence of its typical lip finish, such feature appears like a true varix as also seen in a.o. **Cassidae**.

Tonna perdx (Linnaeus, 1758)
(Plate 5, Figs 3a-c)

Synonyms include (a.o.):

Buccinum perdx Linnaeus, 1758 (original description)

Perdx reticulatus Montfort, 1810

Dolium rufum Blainville, 1829

Dolium plumatum Green, 1830

Tonna perdx fma *paucimaculata* Bozzetti, 2010 **syn. nov.**

Distribution: Common all across the Indo-pacific in shallow water. Known from South Africa across the Indian Ocean to Honshu, Japan and further to Hawaii, Guam and southward to Australia. Juvenile specimens have occasionally been recorded from French Polynesia and New Zealand, yet these represent pseudo-populations recruited as larvae from tropical waters. Also recorded live from the Red Sea.

This species was recorded by Zhang & Ma (2004: 80) from South China Sea (Paracel-Islands area) and south-east and south-west Taiwan. The specimens in the collection of the present author are also from South China Sea (offshore in shallow water) and Taiwan.

Remarks: The most striking about this species is the variation in colour and pattern of its shell. The exact reason for this variation has as yet not been established, yet this species appears to be more sensitive to habitat conditions and also has a broader diet. So far, 5 different species of Holothuria have been recorded as being a part of the diet of *T. perdx* (Morton, 1991: 12). Furthermore, the protoconch also seems sensitive to colour variation, which presumably finds its origin in the long pelagic stage yet for which no conclusive explanation is available today.

The variation in colour and pattern of the shell has lead to the description of synonyms and forms in the past, and is in scientific terms of no added value to the knowledge of the animal (which bears the name *T. perdx*). In that respect, the name *Tonna perdx* fma *paucimaculata* Bozzetti, 2010 is here considered a synonym.

Tonna zonata (Green, 1830)
(Plate 6, Figs 1a-b; Plate 7, Figs 1a-c)

Synonyms include (a.o.):

Dolium zonatum Green, 1830 (original description)

Dolium crenulatum Philippi, 1845

Tonna olearium (Linnaeus, 1758) (unnecessary recombination of unrelated taxon)

Distribution: Indo-Pacific. From South Africa to the Philippines and north to Honshu, Japan, and southwards to New Zealand.

This species was recorded by Zhang & Ma (2004: 74 - as *Tonna olearium* (Linnaeus, 1758)) from Hainan, South China Sea all along the Chinese coast to as far north as the area off Taizhou, and from western Taiwan. Reported from the collection of the present author from shallow water in South China Sea (a.o. off Wailingding Dao, Guangdong area) -amongst which specimens which are nearly entirely white, and a more typical coloured specimen of 297mm high- and from Taiwan Strait (in 20m) and East China Sea.

Remarks: This species has erroneously been called *Tonna olearium* (Linnaeus, 1758) by many authors throughout history, as a consequence of very early (mis-) interpretations of Bruguière (1789) and issues with the Linnean material. Beu (2005: 120) discussed the Linnean type material of *Buccinum galea* Linnaeus, 1758, *Buccinum olearium* Linnaeus, 1758 and *Bulla canaliculata* Linnaeus, 1758 and concluded that the name *Buccinum olearium* is synonymous with *Buccinum galea*, a vision subsequently substantiated by Vos (2007: 57). The first available name for this species is the name *Dolium zonatum* which was introduced by Dr. Green in 1830. The type specimen of Dr. Green is presumed lost, and Vos (2007:66) designated a specimen from the MNHN, Paris which was collected during one of the Taiwan-expeditions as neotype. As such, the type locality for this species becomes "Taiwan" (by neotype designation).

Tonna chinensis (Dillwyn, 1817)
(Plate 8, Figs 1a-d)

Synonyms include (a.o.):

- Buccinum australe seu chinense* Chemnitz, 1795 (nomen illegitimum)
- Buccinum chinense* Dillwyn, 1817 (original description)
- Dolium australe* Mörch, 1853
- Dolium pictum* Schepman, 1893
- Dolium magnificum* G. B. Sowerby III, 1904
- Dolium schepmani* Bayer, 1937
- Tonna chinensis magnifica* (G. B. Sowerby III, 1904)
- Tonna cumingii* (Reeve, 1849) in Springsteen & Leobrera (1986) (junior homonym)

Distribution: Recorded from the eastern part of the Indian Ocean to the western Pacific, northward to Honshu, Japan and southward to Australia.

Recorded from Chinese waters by Zhang & Ma (2004:69) from Hainan, South China Sea along the Chinese coasts to the area near Quanzhou, and also from Taiwan Strait and southern Taiwan. Specimens from South China Sea, Hong Kong and northern Taiwan (off Chilung) in the collection of the present author.

Remarks: Dillwyn (1817) refers to two drawings in Chemnitz (1795) duly allocating a binominal name to this species rather than the non-binominal (and thus not accepted) name suggested by Chemnitz. As no type material from Chemnitz was found during examination, Vos (2007: 77) designated a neotype bearing sufficient resemblance to Chemnitz' drawings from a sample of specimens from Vietnam. The type locality becomes as such "Vietnam" (by neotype designation).

The name *Dolium magnificum* was introduced by G. B. Sowerby (III) for a specimen of *Tonna chinensis* (Dillwyn, 1817) which has a slightly thicker and heavier shell, yet is in all primary characteristics identical to the latter.

In a time when the true identity of *Tonna chinensis* (Dillwyn, 1817) was hardly known, Springsteen and Leobrera (1986: 100; pl. 26, fig. 2) showed two specimens of *T. chinensis* -of which one young specimen- and listed them under the name *Tonna cumingii* (Reeve, 1849). Their publication was for a long time one of the few sources for that area, and as such the presently discussed species has erroneously been referred to as *T. cumingii* in many subsequent publications and on many websites. The true identity of *T. cumingii* (Hanley in Reeve, 1849) was discussed by Vos (2007: 80) after rediscovery of the type material of that taxon. At present, there are no confirmed records of *T. cumingii* in Chinese waters.

Tonna melanostoma (Jay, 1839)
(Plate 1, Figs 1a-b; Plate 8, Fig. 2)

Synonyms include (a.o.):

Dolium melanostomum Jay, 1839 (original description)

Distribution: This species was not listed by Zhang & Ma (2004). It is known from Tonga and New Caledonia, northernmost New Zealand and Norfolk Island, and in the north from around Japan (Takashige, H. and Masuko, H. (both Shizuoka, Japan); pers. comm. 2011). This species was recently also reported from French Polynesia (Beu, Bouchet & Tröndlé, 2012: 106). 3 young specimens (100.8mm; 103mm; 108.03mm) trawled at depths between 350-380m in the East China Sea, and 1 specimen (74mm) trawled at 150m in East China Sea are present in the collection of Dirk De Boe (Belgium); one specimen (92mm) trawled at 300m in East China Sea in the collection of Trevor Young (Queensland, Australia) and one specimen (103.6mm) trawled live on sand bottom at 300m in East China Sea is in the collection of the present author. These most probably represent a pseudo-population originating from larval drift originating from the populations inhabiting the Japanese coasts, which currently find sufficient food sources and a suitable habitat at great depth on the shelf between mainland China and Kyushu, southern Japan.

Remarks: For a long time, this species was confused with the endemic Hawaiian species *Tonna hawaiiensis* Vos, 2007 until Vos (2007: 94) separated the two. In that respect, Vos (2007: 97) treated *T. melanostoma* as a part of the *Tonna variegata*-complex, yet this magnificent species is much closer related to *T. chinensis* and *T. cumingii* based on the spiral sculpture, as can clearly be seen in the young specimens trawled in the East China Sea.

Tonna luteostoma (Küster, 1857)
(Plate 8, Figs 3a-b)

Synonyms include (a.o.):

Dolium luteostomum Küster, 1857 (original description)

Dolium favannii Hanley, 1860

Dolium japonicum Dunker, 1867

Dolium porcellarum Euthyme, 1885

Distribution: Uncommon. Recorded from throughout the Indian Ocean to the western Pacific; eastwards from South Africa to Japan and southwards from Japan to New Zealand.

Recorded from Chinese waters by Zhang & Ma (2004:74) from East China Sea north-east of Taiwan. Specimens in collection of the present author originate from South China Sea, from off Hong Kong (trawled 60-120m deep), from north and south-west Taiwan (trawled 50-100m deep) and from East China Sea (trawled 180-220m deep).

Remarks: This species is very distinct and is rarely cause of confusion. Young specimens resemble *Tonna variegata* (Lamarck, 1822) yet are easily distinguished by the impression of the outer spiral sculpture in the inner side of the aperture.

Species with doubtful occurrence records

Tonna boucheti Vos, 2005
(Plate 9, Figs 1a-b)

Synonyms include (a.o.):

Tonna boucheti Vos, 2005 (original description)

Distribution: Vos (2005: 50-51) described this species based on material in his own collection, and in the collection of David and Kevin Monsecour (Belgium), which they had simultaneously obtained a number of years earlier from the late Dan Spelling (USA). On the accompanying labels, the locality was indicated as "Taiwan, Kaoshiung,

1994, at 100 metres". As such, the species was described with type locality "Taiwan; Kaoshiung". Apart from the original material, very little material has been found or observed since. One specimen in the collection of the present author originates from "South China Sea" yet without further specifications. The drawing of *T. chinensis* in Zhang & Ma (2004: 68) strongly resembles this species, and is more likely to have been a specimen of *T. boucheti* rather than *T. chinensis*. Until more material with better and more accurate locality data is obtained and examined, it is assumed that this species inhabits deeper waters (> 100m) south-west of Taiwan and the South China Sea (also see Vos, 2005:51).

***Tonna rosemaryae* Vos, 1999**
(Plate 9, Figs 2a-b)

Synonyms include (a.o.):

Tonna rosemaryae Vos, 1999 (original description)

Distribution: Vos (1999: 43) described this species from the Gulf of Aden, from the corner Djibouti - Somalia. Some years after the description, a specimen was offered, originating from "Kaoshiung, Taiwan, 1995, at 100 mtrs." (also see Vos, 2007, pl. 49, fig. 5), being the exact same locality annotation as the *T. boucheti*.

For this species, it is here concluded that the dealer from whom it was obtained, most probably obtained it from Taiwanese fishermen -possibly living in or near Kaoshiung- but that the specimen was not taken off Taiwanese coasts. As such, it is here not considered a part of the fauna of Chinese waters, and such until more specimens with more accurate locality details are reported from Chinese and adjacent waters.

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Plate 1:

1a-b: *Tonna melanostoma* (Jay, 1839) coll. C. Vos ref. TT316; New Caledonia; 300mm. Large female; insert (Fig. 1b) shows the outer lip constructed lower than the canal, as well as traces of the egg mass in the aperture.

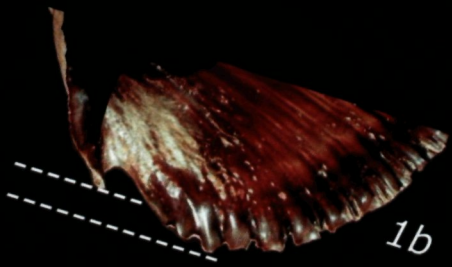
2a-c: *Tonna galea* (Linnaeus, 1758) coll. C. Vos ref. TT969, Off Ambriz, northern Angola, 137mm. Medium sized female, live taken during "shell growth" phase. The growth phases are also visible in the periostracum (Fig. 2c)

All photographs courtesy of Kenneth Vos (Scherpenheuvel, Belgium)

1a



1b



2b



2c



a



1



2a



2b

Plate 2:

1a-b: *Tonna lischkeana* (Küster, 1857); coll. Royston Koh (Singapore); Singapore. 118mm. Live taken, and preserved with periostracum. The radula and hooked jaws (Fig. 1b) measure resp. 16mm and 6mm. Photograph courtesy of Royston Koh (Singapore).

2a-b: *Tonna perdix* (Linnaeus, 1758): Philippines, Siquijor, at 9m during night dive.
a: Animal fully extended when "racing" over the ocean floor in search of food.
b: This picture shows how the *Tonna* places the proboscis on a prey (Holothuria) and starts hauling it in. In this case, the Holothuria inflated (in defence) and the *Tonna* had to let go after about 5 minutes. (Photograph and observation information courtesy of Guido T. Poppe)

Plate 3:

1a-e: *Eudolium crosseanum* (di Monterosato, 1869)

a-b: coll. C. Vos ref. TE002, Trawled at 70-100fms off south-west Taiwan, 54.6mm. Protoconch slightly damaged. Typical elongated shape and clear example of the typical spiral sculpture for this species. Colour pattern very faded, and as such closely resembling the holotype.

c-d: coll. C. Vos ref. TE039, Dredged at 140-200m off south-west Taiwan, 66.25mm. Protoconch intact. Typical elongated shape, and spiral sculpture clearly visible through elaborated colour pattern. Fine example with a straight canal and delicately elaborated lip.

e: Live specimen trawled at 60-80m East China Sea

2a-c: *Eudolium bairdii* (Verrill & Smith in Verrill, 1881)

a: coll. C. Vos ref. TE057, Trawled live in mud in 200m, East China Sea, 58.8mm. Protoconch slightly damaged. Shape typical of the species; elongated, with a straight canal and thin, delicately elaborated outer lip. The spiral sculpture is visible through the coloration and the primary cords on the shoulder are entirely smooth.

b-c: coll. C. Vos ref. TE040, Dredged at 140-200m off south-west Taiwan, 62mm. Protoconch intact. Shape typical of the species, yet spiral sculpture opposite extreme from the previous specimen, as the primary cords on the shoulder and the first half of the last whorl are very nodulose.

3a-b: *Malea pomum* (Linnaeus, 1758); coll. C. Vos ref. TM029, Taiwan, 41mm. Medium sized specimen, with the typical "notch" of the genus *Malea* on the apertural side of the columella not yet fully developed. Outer lip shows the typical denticulate lip which is elaborated after a growth phase.

All photographs courtesy of Kenneth Vos (Scherpenheuvel, Belgium), except figure 1e: courtesy of He Jing (Shanghai, China).



Plate 4:**1a-e:** *Tonna allium* (Dillwyn, 1817)

a-b: coll. C. Vos ref TT482 In shallow water on sand, South China Sea, 71mm. Quite typical shape of the species, with the denticulate lip finished after the growth phase, and the canal twisted "like a string of cords". Spiral sculpture very typical. Please note the first and second primary cords, which give the shell its typical shape. In general, the coloration is very variable, as can be noticed in this specimen.

c-d: coll C. Vos ref. TT270, Taiwan, 50.8mm. Dwarf-like specimen with a large part of the periostracum preserved. Occasionally, some callus can occur on the columella, as can be seen in the apertural view, otherwise very typical specimen.

e: coll. C. Vos ref TT673, In shallow water, Taiwan, 60.3mm. The dorsal view illustrates the phased growth through the whitish line on the right (end of a previous growth phase after which the lip was dissolved), and the "breakline" left from the centre, which is a non-dissolved lip and the continuation of the shell growth following that phase.

2a-b: *Tonna dolium* (Linnaeus, 1758) coll. C. Vos ref. TT414, Palawan, Philippines, 82.8mm. It is unsure whether this species actually occurs in Chinese waters and is here illustrated for comparison purposes to the other species on this plate. In its typical form, it has few (fewer than 10) broad and rounded primary spiral cords, with sometimes secondary, and even tertiary cords in the interspaces. The canal is straight to twisted, yet showing a similar "twist of cords" like *Tonna allium* (Dillwyn, 1817). The lip finish before a rest phase is simple, with merely a slight thickening of callus on the inner lip.

3a-c: *Tonna lischkeana* (Küster, 1857)

a-b: coll. C. Vos ref. TT967 Taken from sand bottom at 220m deep, East China Sea, 97.7mm. Very typical specimen with periostracum largely preserved. Typical spiral sculpture, which consists of multiple (more than 10) primary cords with sometimes secondary cords in the interspaces. The typical general shape is spherical, with an elongated twisted canal and sometimes a little white callus on the columella. The lip finish in rest phase is simple, with only a slightly thickened callus on the inner lip.

c: coll. C Vos ref. TT913, Taken 50-100m deep, southern Taiwan, 103.5mm. Typical specimen with periostracum largely preserved and very typical spiral sculpture and coloration.

4a-b: *Tonna tessellata* (Lamarck, 1816) coll. C. Vos ref. TT009 Taiwan, 56.1mm. Rather small, yet very typical specimen in shape and colour elaboration. Key characteristics of the lavishly elaborated outer lip and the callus over the canal twist -and thus covering the umbilicus- well visible.

All photographs courtesy of Kenneth Vos (Scherpenheувel, Belgium)

Plate 4



Plate 5: (all photographs courtesy of Kenneth Vos (Scherpenheувel, Belgium))

1a-c: *Tonna canaliculata* (Linnaeus, 1758)

a-b: coll. C. Vos ref. TT074, Off Nha Trang, Vietnam, 118mm. Typical spherical specimen (female), breakable, thin shell and very light in weight. The rounded and elevated shoulder give it the typical deep canal along the suture after which it was named. The canal is straight and simple, and some white callus can occur on the columellar area. The specimen was taken during a growth phase, and as such the lip is sharp without any elaboration. The spiral sculpture of this specimen consists of broad and rounded, slightly elevated spiral cords with small interspaces, yet this sculpture is subject to variation.

c: coll. C. Vos ref. TT072, Off Nha Trang, Vietnam, 88.38mm. Typical specimen (male) with hardly any elevation of the primary spiral cords and a much less elaborated coloration.

2a-d: *Tonna sulcosa* (Born, 1778)

a-b: coll. C. Vos ref. TT489 In shallow water, South China Sea, 121mm. Very typical specimen of the species as where general shape, lip elaboration, canal twist and coloration are concerned. In general, this species has a more elevated spire and belongs to the less spherical **Tonnidae**. The spiral sculpture mostly consists of flat and low primary cords with narrow interspaces, with the exception of the adapical cord on the shoulder -and sometimes the subsequent one or two as well- which is rounded. Entirely white and mostly brown specimens have been recorded from various locations, yet in typical colour pattern, there are 3 to 4 chocolate brown bands evenly distributed over the whorl height.

c-d: coll. C. Vos ref. TT388 Trawled by Hong Kong shrimper in 40-60 fathoms on muddy sand bottom off Wailingding Dao, South China Sea, 48.5mm. Small male specimen with all typical characteristics -including the black protoconch- and periostracum largely preserved. The side view perfectly shows how the lip was not dissolved after the last "rest" phase, and the shell continued leaving a double lip which reminds of a varix.

3a-c: *Tonna perdix* (Linnaeus, 1758)

a-b: coll. C. Vos ref. TT272 from off Taiwan, 124.5mm. Very typical specimen showing the typical elongated and oblong shape of the species, as well as its typical design after which it was named even though the periostracum is largely preserved. The spiral sculpture consists of low, broad and rounded primary cords with narrow interspaces. In some specimens, this sculpture -like in *Tonna canaliculata* (Linnaeus, 1758)- can be nearly obsolete. The specimen shown here has a well elaborated spiral sculpture. The canal is fine and sharp, and usually bent towards the aperture. Quite often, a white to creamy-brown callus is present on the columellar area. The lip is simple and sharp, and only slightly thickened after a growth phase.

c: coll. C. Vos ref. TT483 In shallow water on sand, South China Sea, 90.6mm. Typical specimen as where general shape and morphological characteristics are concerned. The typical pattern is elaborated in a different way giving a paler look.

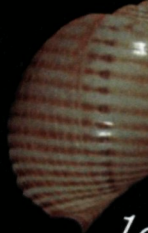
1a



1b



1c



2a



2b



2c



2d



3a



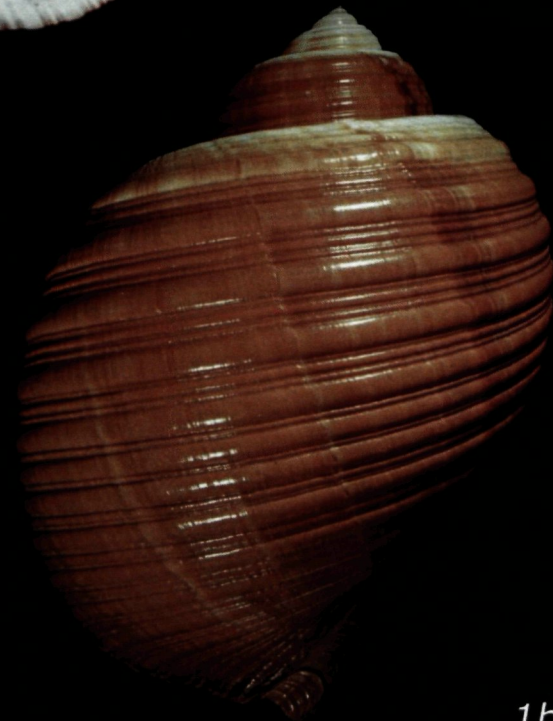
3b



Plate 6



1a



1b

Plate 6:

1a-b: *Tonna zonata* (Green, 1830) coll. C. Vos ref. TT917 Trawled by fishermen in shallow water on sand, South China Sea, 297mm. Very large specimen of the typical shape of this species, well showing the typical -and little variable- spiral sculpture and most frequently encountered colour. The spiral sculpture consists of broad and rounded, widely spaced primary cords, with secondary and tertiary cords in the interspaces. The apex is usually white, and a white band is formed along the suture whilst the rest of the whorls is brown. The canal is straight and elongated, with occasionally some callus partially covering the umbilicus. The lip is sharp and simple, and is only slightly thickened in "rest" phase. Some callus can occur on the columellar area.

All photographs courtesy of Kenneth Vos (Scherpenheugel, Belgium)

Plate 7:

1a-c *Tonna zonata* (Green, 1830)

a-b: coll. C. Vos ref. TT494 In shallow water, South China Sea, 133mm. Small specimen, nearly all white, yet showing all main morphological characteristics of the species: spiral sculpture, slightly thickened lip indicating capture during rest phase, and straight and elongated canal.

c: coll. C. Vos ref. TT641 In shallow water, South China Sea, 208mm. Medium sized specimen with most of the periostracum intact, showing the shell "in natural condition" yet with all main characteristics visible.

All photographs courtesy of Kenneth Vos (Scherpenheugel, Belgium)

1a

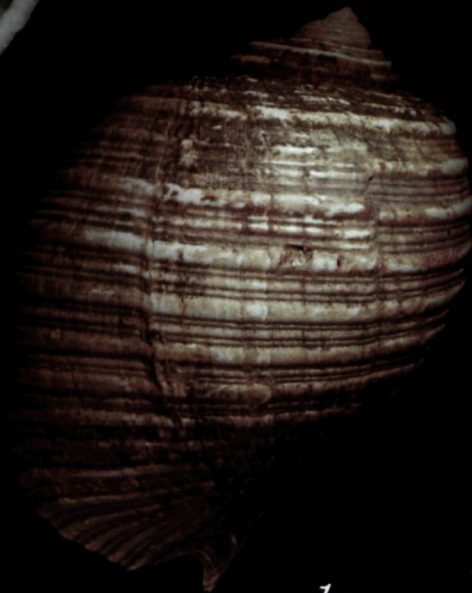
Plate 7



1b



1c



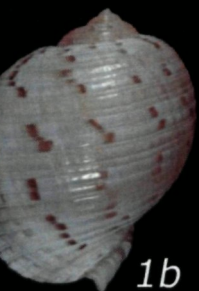


Plate 8:**1a-d:** *Tonna chinensis* (Dillwyn, 1817)

a-b: coll. C. Vos ref. TT218 Taken by prawn trawler off Hong Kong, 85.8mm. Very representative specimen of the species as where morphological characteristics are concerned. The key identifier for this species is the spiral sculpture -specifically in the upper half of the last whorl- consisting of broad and flat primary cords alternated with a narrower secondary cord, separated from each other by a mere groove. In younger specimens, the primary cords are more rounded and also more elevated than the secondary cords. These roundings flatten out later on to a more even sculpture. The general shape is round and spherical, and the canal is straight yet with a strong twist of a prominent cord along the umbilicus. The lip is finished simply as a thickening on the inner side of the lip after a growth phase. The colour pattern is highly variable yet usually includes banding. Entirely dark brown specimens have been recorded in the Philippines.

c-d: coll. C. Vos ref. TT514 Dredged at 140-200m, southwest Taiwan, 94mm. Slightly thicker and heavier specimen than the previous, closely resembling the holotype of *Dolium magnificum* (G. B. Sowerby III, 1904) (= *Tonna chinensis* (Dillwyn, 1817)). The typical spiral sculpture is clearly visible, as are the other main morphological characteristics.

2: *Tonna melanostoma* (Jay, 1839) coll. C. Vos ref. TT968 live taken on sand bottom at 300m East China Sea, 103.6mm. Lip badly damaged but dorsal very clearly showing the main morphological characteristics of the species. Young specimen and shell very thin and breakable. Spiral sculpture of flat, rounded primary cords with narrow interspaces, in which an occasional secondary cord can occur. General shape spherical. Colour pattern in the young stage more banded, yet more monochrome in the adult stage.

3a-b: *Tonna luteostoma* (Küster, 1857) coll. C. Vos ref. TT808 Trawled from East China Sea in about 180m deep on sand bottom, 183mm. Typical specimen with a low spire and spherical general shape. The spiral sculpture consists of broad, rounded and elevated spiral cords, with narrow interspaces in between. This lavish spiral sculpture is transposed to the inside where it occurs as widely spaced ridges. The canal is straight with a prominent cord along the umbilicus, and in most specimens the canal is covered with a thick white callus, which is also visible on the columella in most specimens. Lip finish is sharp and simple with hardly any thickening in the rest phase.

All photographs courtesy of Kenneth Vos (Scherpenheuvel, Belgium)

Plate 9:

1a-b: *Tonna boucheti* Vos, 2005 coll C. Vos ref. TT083 paratype 1 "Taiwan, Kaoshiung, 1994. At 100 metres", 68.1mm. Small specimen, shell thin and breakable with typical general shape and spiral sculpture. The general shape resembles that of *Tonna chinensis* (Dillwyn, 1817), but the spiral sculpture of *Tonna boucheti* (Vos, 2005) consists of narrow, rounded and elevated primary cords, with interspaces of approximately the same size as the primary cords. Secondary cords only occasionally occur as where this is a main feature of *Tonna chinensis* (Dillwyn, 1817). Even in the young stage, specimens of the latter species clearly show the secondary cords which complete the typical spiral sculpture of that species, a feature completely lacking in *Tonna boucheti* Vos, 2005. The canal is straight and gently twisted, without callus on columella nor canal. In rest phase, the lip is finished with a mere thickening on the inside.

2a-b: *Tonna rosemaryae* Vos, 1999 coll. C. Vos ref. TT143 " Kaoshiung, Taiwan, 1995, at 100 metres.", 97mm. General shape broadly shouldered and spherical. Spiral sculpture of broad rounded primary cords which are more widely spaced on the upper half of the whorl and closer together on the lower half. Secondary threads can occur in the interspaces. Most striking feature is the yellowish orange inner colour of the aperture. Lip sharp in growth phase, and only slightly thickened in the rest phase.

All photographs courtesy of Kenneth Vos (Scherpenheuvel, Belgium)

1a



1b



2a



2b

