Chapter

Biometrics of Aquatic Animals

Mahmoud M.S. Farrag

Abstract

This chapter is a part of the book "Recent advances in biometrics" introduces the importance of biometrics in the aquatic studies in brief view. Biometric measurements (Morphometric, meristics and description) are widely used in various fields' "taxonomy, species identifications, monitoring of pollution, species abnormalities, comparison, environmental changes, growth variation, feeding behavior, ecological strategies, stock management, and water quality of aquaculture. These data were collected from several articles and books of aquatic animals and presented both applications and required considerations for biometric implementations. It is important also to detect sexual dimorphism, adaptations during evolutionary time and diminishing intraspecific competition by increasing niche portioning. The biometrics could be applied for various aquatic organisms as dolphins, sharks, rays, mollusca, crustaceans, protozoa, ... etc. and for specific organs like teeth, otolith and appendages by different techniques and preservations. Scientists are still applying these measurements even with the presence of advanced techniques like PCR as they are low in cost, faster and more applicable. This chapter also presented some recent trends including animal's biometric recognition systems, followed by challenges and considerations for the biometrics implementations. It is recommended to apply biometrics in wide range together with modern techniques considering the specificity of its quality and preservation status.

Keywords: biometrics, importance, applications, aquatic sciences, considerations

1. Introduction

The biometrics is a Greek word divided in to two parts "bio" means life and "metrics" means measurements. Biometric science is an old science concerning the documentation of the features or bio measurements or identification characteristics of the targets which could be human, animals and even fossils. It has been used to describe and record the measurement and biological data for, both animal and human (tracking of the similarities of life forms). It is based on anatomic uniqueness of an individual and specificity of physiological and behavior characteristics. Biometrics approach based on behavior characteristics is less expensive and less dangerous for the user; while physiological approach offers highly exact of identification. However, both kinds provide high level of identification than others like passwords and cards.

In general, biometrics were applied in different platforms [1] as follows.

- Criminalistics (using of biometric identifiers to recognize victims, unknown body and prevent kidnapping for identified children).

- Marketing (using of biometrics to identify owners of loyal cards)
- Time accounting systems at work, schools, etc.
- Security systems (to control the access to the rooms and the internet resources)
- Voting system (to identify/authenticate a person who takes a part in voting during the functionality of voting system).
- It used as apart in passport informations as an international required by various organizations such as demands ICAO standards which involve biometrics in passport.
- Biometrics identifiers are used also for registration of immigrants and foreign workers among immigration Affairs. It allows identifying people even without documents.

In animal, a biometric identifier or measurable could be found as robust and distinctive physical, anatomical or molecular trait that can be used to uniquely identify or verify the claimed identity of an animal [2]. Among the advantages of biometrics usage, it does not cause pain or change in the appearance of organisms. For this reason and others, this chapter focuses on the biometrics in animals particularly aquatic organisms. Their analysis can be considered as a first step to investigate the stock structure with large population sizes. The morphological differentiation of partially-isolated stocks due to environmental differences in the habitats could be known as phenotypic markers [3]. The interactive effects of environment produce morphometric differences within a species, variability in growth, development, and maturation creating a variety of body shapes within a species [4–6]. Hence, it is necessary to identify specimens correctly and investigate other biological traits as growth, mortality, fecundity, trophic relation, parasite relationship, historical and paleontological events [7]. The biometric measurements could be applied on different aquatic organisms as sharks, Rays, Mollusca, Crustaceans, Protozoa, etc. and even for different organs like teeth, otolith and appendages.

It is well known that morphology is directly related to species life history and habitat use. Thus, fish morphometric analysis represents an important tool to determine their systematic, growth variation, population parameters and environmental relationships [8–10]. It also, covers several fields of research such as: ecomorphology evaluating the role of environmental pressures on shaping species diet, feeding behavior, ecological strategies, niche partitioning, habitat use and trophic structure population ecology and metapopulations studies, investigating differences in body shape among populations spatially isolated [9–12]. In addition to that, males and females of the same species may be identified as different species because the intraspecific characteristics, therefore information about morphological sexual variation is important to avoid species misleading identification [13–16]. Moreover, the sexual dimorphism is an important evolutionary adaptation mechanism, and to diminishing intraspecific competition by increasing niche portioning [16, 17]. It establishes the relationship between morphology and behavior, elucidating possible ontogenetic niche shifts and the evolutionary plasticity of an organism [18].

Many biologists and taxonomists are still studying the external biometrics (morphometric and meristics) of the organisms in various research fields, even with the presence of molecular biology techniques, giving faster, and low-cost results [19–23].

From another view, the species identification and population discrimination are important in the biodiversity conservation, natural resources, and fisheries management. In certain cases, particularly when we lost some biometric characters for species identification due to sampling and handling processes, we need intensive measurements. So, the modern morphometric technique needed to be applied; as truss network technique (**Figure 1**); it is applied to provide supplementary taxonomic information to enhance the species identification. It could be used also in case of unclear diagnostic characters available for the identification of species as in ariids species which have overlapped characteristics among several species. This technique was provided by Turan et al. [24] and Abdurahman et al. [25]. In addition, the implementation of biometrics could be applied on the internal parasite and used as species identification of host and as a sexual dimorphism indicator [26], the later author studied the impact of Sacculina sp. parasites, Rhizocephalans (Sacculinidae) on two host crabs *Leptodius exaratus* and *Actaea hirsutissima* in Egypt. Over few years, animal biometrics has become an emerging area of research in computer vision and animal cognitive science [27]. The progress has pointed recognition and modeling systems for the animal biometrics, they are being demonstrated in the real-time applications and applicability for representing and detecting the phenotypic appearance of species, visual features, individuals, behaviors, and morphological characteristics of species [28]. These methods can provide better efforts for designing of emerging algorithms, frameworks, and systems for identification and representation of appearances of species in the emerging field of animal biometrics [28, 29]. Beside the importance of biometrics that has been presented above, the present chapter introduces some applications of biometrics in aquatic animals with the considerations for applying biometrics.

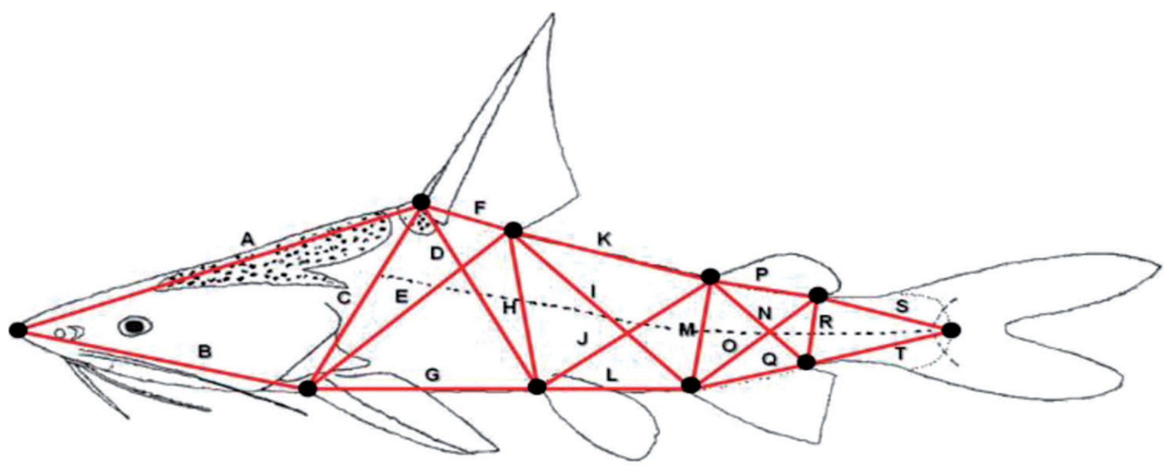
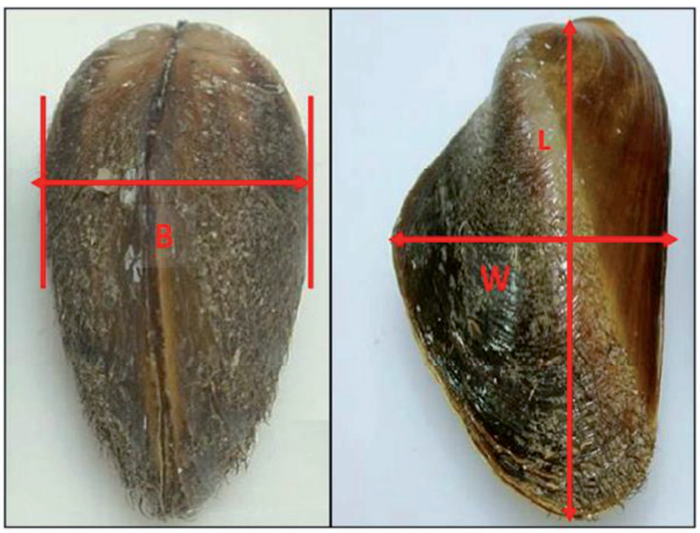


Figure 1.
Truss network distances of ariids family. A: snout to first dorsal fin; B: snout to pectoral fin; C: pectoral fin to F. dorsal fin; D: origin of dorsal fin to pelvic fin; E: pectoral fin to end of dorsal fin; F: origin of dorsal fin to E. dorsal fin; G: pectoral fin to pelvic fin; H: end of dorsal fin to pelvic fin; I: end of dorsal fin to F. anal fin; J: pelvic fin to F. adipose fin; K: end of dorsal fin to F. adipose fin; L: pelvic fin to F. anal fin; M: first of adipose fin to F. anal fin; N: first of adipose fin to E. anal fin; O: anal fin to E. adipose fin; P: length of adipose fin; Q: length of anal fin; R: end of adipose fin to E. anal fin; S: end of adipose fin to caudal fin; and T: end of anal fin to caudal fin.

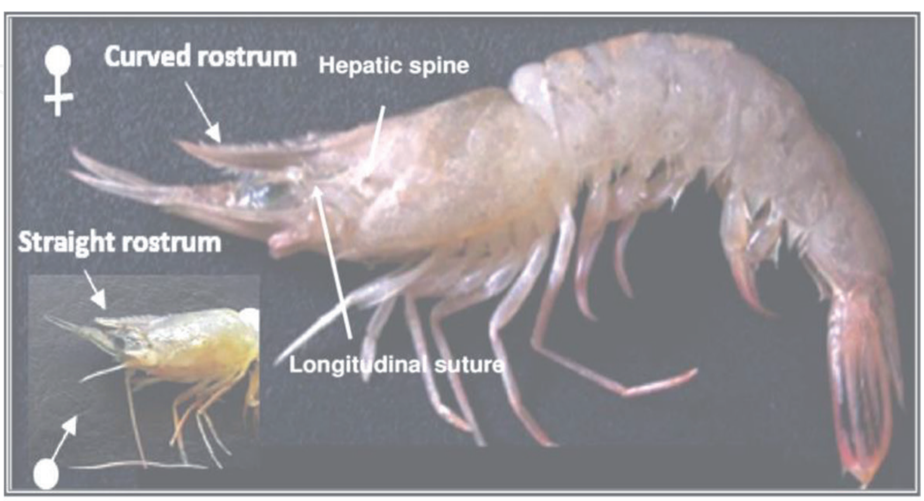
2. Some of biometric implementations

2.1 Sexual dimorphism

Sexual dimorphism is an important to distinguish males and females. Paiva et al. [30] studied the ontogenetic sexual dimorphism of *Genidens genidens* from the Guanabara Bay, Brazil by applying the morphometric measurements (12 body measurements), for different sexes and different maturity stages. Pearson's linear correlation revealed a significant positive correlation between total length and all other body measures, except for base adipose fin, mouth depth and eye depth for immature females. A significant difference between maturity stages for each sex, indicating a variation in morphometric characteristics driven by sexual dimorphism. Moreover, the differences among all maturity stages indicated an ontogenetic morphological



(a)



(b)

Figure 2.
a. Photographs showing M. auriculatus *morphometeric measurement. L (length), W (width), and B (bottom) [31]. b. Lateral view photograph of fresh adult male and female of southern rough shrimp* T. curvirostris *(Stimpson, 1860) [32].*

difference that started in mature individuals only. The morphometric measurements were applied also on Mollusca (*Modiolus auriculatus*) from the Red Sea, Egypt [31]. The length measurements were applied seasonally and according to sex, to evaluate the changes in sex and growth. (**Figure 2a**). The use of biometrics also was applied by Sharawy et al. [32] on shrimp *T. curvirostris* (Stimpson, 1860) to differentiate males and females (**Figure 2b**).

In this example, it is another application of biometrics on other category of biota "cephalopoda," the morphometric characters of male and female *Sepia pharaonis* from Suez Gulf, Egypt were applied for the whole animal and some internal parts. (**Figures 3a–c**) [33].

The another biometric differentiation was used also for sexual dimorphism of three carangid species (*Carangoides ferdau*, *Carangoides malabaricus*, and *Gnathanodon speciosus*) from the Red Sea, Egypt [16]. The basic statistics of the morphometric indices

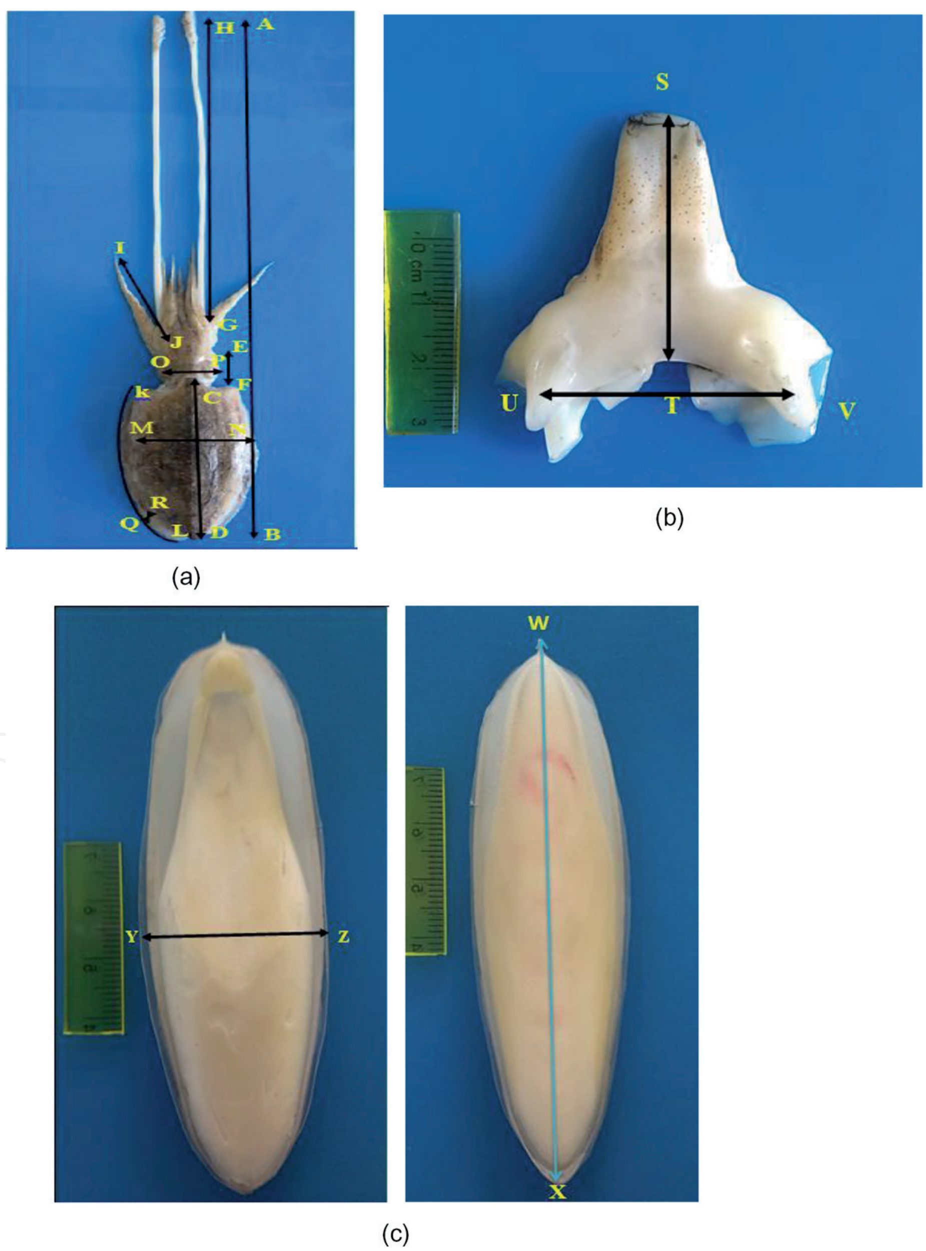


Figure 3.
The different morphometric measurements of S. pharaonis *a; body dorsal view, b: funnel and c: cuttlebone (dorsal view and ventral view).*

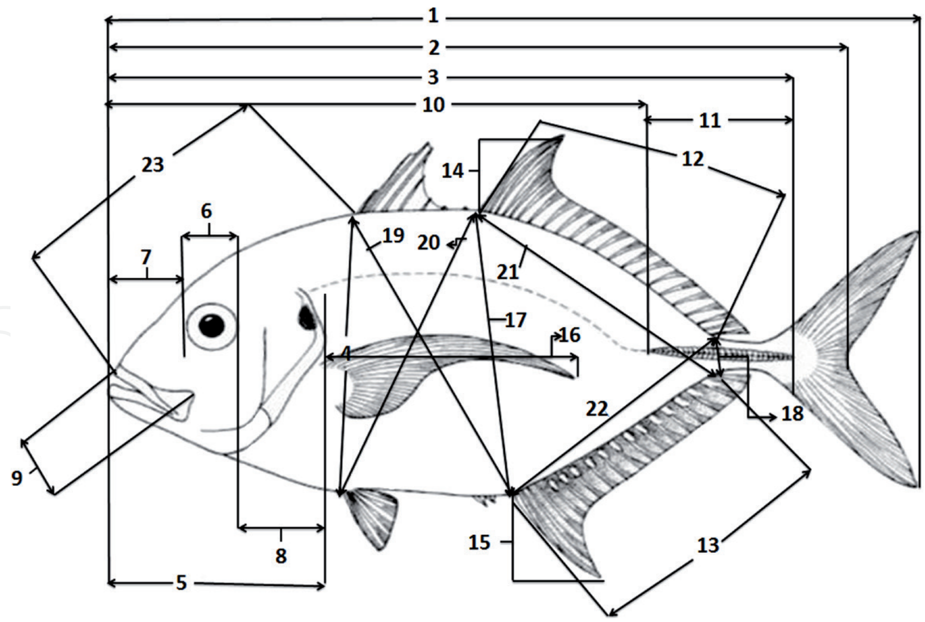


Figure 4.
Schematic illustration of measurements taken on the body of the Three Carangidae Specie considered from the southern Red Sea, Hurghada, Egypt. 1. total length (TL); 2. fork length (FL); 3. standard length (SL); 4. body depth (BD); 5. head length (HL); 6. eye diameter (EyD); 7. snout length (SnL); 8. postorbital length (POL); 9. upper jaw length (UJL); 10. curved lateral line segment length (CLL);11. straight lateral line segment length (SLL); 12. soft dorsal fin base length (SDFL); 13. soft anal fin base length (SAFL); 14. soft dorsal fin height (SDFH); 15. soft anal fin height (SAFH); 16. pectoral fin length (PFL); 17. distance between the first soft dorsal fin ray and the first soft anal fin ray (SDSAFL); 18. distance between anal and dorsal fin insertions (ADFEL); 19. distance between the first spine of the dorsal fin and the first soft anal fin ray (SpDASFL); 20. distance between the first soft dorsal fin ray and ventral fin origin (SDVOFL); 21. distance between the first soft dorsal fin ray and the insertion of anal fin (SDEAFL); 22. distance between the insertion of dorsal fin and the first soft anal fin ray (EDSAFL); 23. predorsal fin length (PRDFL).

(relative to SL or HL) of the three carangid species considered sexual dimorphism (**Figure 4** general diagram) regarding some indices that are size-free and valid as a discriminating tool between males and females of the examined species.

2.2 Light and scanning electron microscopy of internal parasites

The biometric investigations play a role in the field of parasitology and micro examinations. Golemansky and Todorov [34], studied the morphology and biometry of eight marine interstitial testate protozoa, amoebae (*Centropyxiella lucida*, *Cyphoderia littoralis*, *Messemvriella filosa*, *Ogdeniella elegans*, *O. maxima*, *Pomoriella valkanovi*, *Pseudocorythion acutum* and *Rhumbleriella filosa*) by light and scanning electron microscopy. All of them were recognized as a size-monomorphic. By their size frequency distributions, the shell length of *P. acutum* and *O. elegans* were characterized by a not well-expressed main-size class in favor of subsidiary classes, but all species have a shell length ranges in close limits (**Figure 5**).

Another example for using the biometrics, is its application for certain parts like fish scales, since its morphology and ultrastructure characteristics are important for fish identification, taxonomy and phylogeny. The biometrics were applied on the scale morphologically and also on the electron scanning picture of *Acanthopagrus bifasciatus* from the Red Sea, Egypt. A wide spectrum of intraspecific variation between different body regions was recorded in terms of scale morphometric indices and primary and tertiary radii counts. The scale characters including rostral field, outer and inner lateral circuli, grooves, denticles, focus region, granulation in

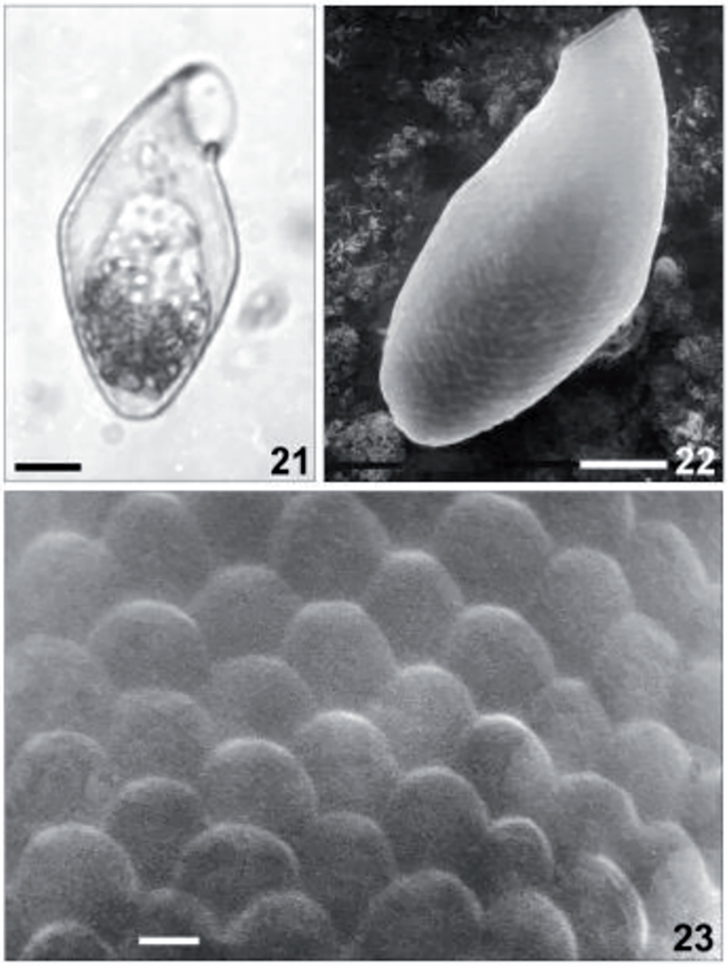


Figure 5.
(21–23). Cyphoderia littoralis. **21**—*lateral view;* **22**—*lateral view;* **23**—*shell structure, showing the imbricated silicious plates (idiosomes) on the shell surface. Scale bars 10 μm (21, 22); 1 μm (23).*

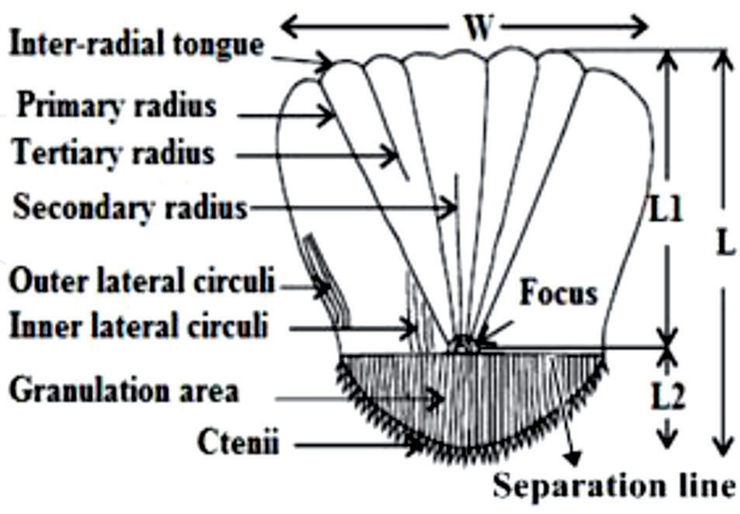


Figure 6.
Schematic drawing scale of A. bifasciatus *showing the different regions, terms and morphometric measurements.*

caudal field and lateral line canal were studied (**Figure 6**) [35]. The ultrastructure by scanning electron microscope (**Figure 7a** and **b**).

Jawad et al. [36] applied the biometric characteristics on another part such as otolith of two species of parrotfish, family Scaridae, from the Red Sea coast of Egypt.

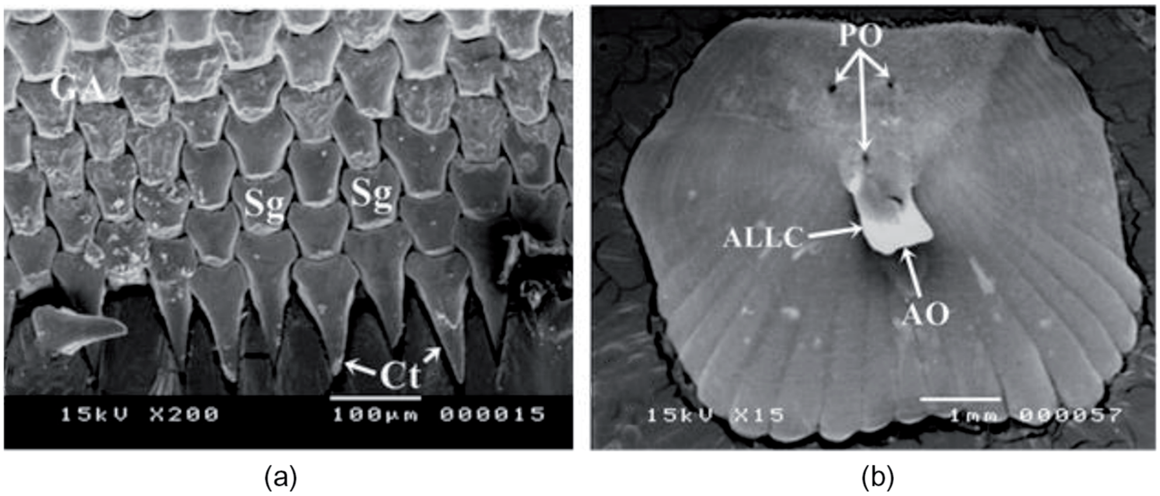


Figure 7.
(a and b): Scanning electron micrographs show scales of A. bifasciatus*; (a): the form of ctenii and segments and (b) the lateral line canal with anterior opening and three posterior opening. Ctenii (Ct), segments (Sg), granulation area (GA), anterior lateral line canal (ALLC), anterior opening (AO) and posterior opening (PO).*

It was applied to identify the most appropriate taxonomic characters that compare or separate these species. Ontogenetic changes in the otoliths of the two scarid fishes become evident. In the otoliths of *Chlorurus sordidus*, *Hipposcarus harid* the characteristics like otolith width, otolith depth, mesial surface shape, lateral surface shape, shape of sulcus acusticus, rostrum and size of rostrum were comparable in small-sized adult fishes, while otoliths of young adults (GI) differed from the adult ones in such characteristics. (**Figure 8a** and **b**).

2.3 Abnormalities in the larval morphology in relation to water quality

The understanding of normal morphology of larvae is very important in aquaculture especially in hatcheries, to evaluate culture conditions for the juveniles and adults. The morphology is an indicator of the abnormalities in the larval morphology in relation to water quality, for production the high-quality individuals [37]. The later author described the allometric growth of Sea bream larvae reared under intensive and extensive conditions, and examined the effect of these conditions on their morphometric proportions; they stated that the intensive marine hatcheries may face many rearing conditions that may reduce the quality of the reared fish, compared to that of the wild ones. These may result in the absence of a swim bladder [38]; osteological and morphological malformations [39], and extra……. The abnormalities in aquatic animals can influence the biometric features, from the modern methods is x-ray utilization, it was applied on three fish species collected from Jubail Vicinity, Saudi Arabia, Arabian Gulf [40] and presented in (**Figure 9**).

2.4 As a comparative key in different habitats

The biometrics were used as comparative tools for species from different habitats and evaluate the effect of environmental conditions. Farrag et al. [20] investigated the biometrics and meristics of puffer fish species *Lagocephalus sceleratus*

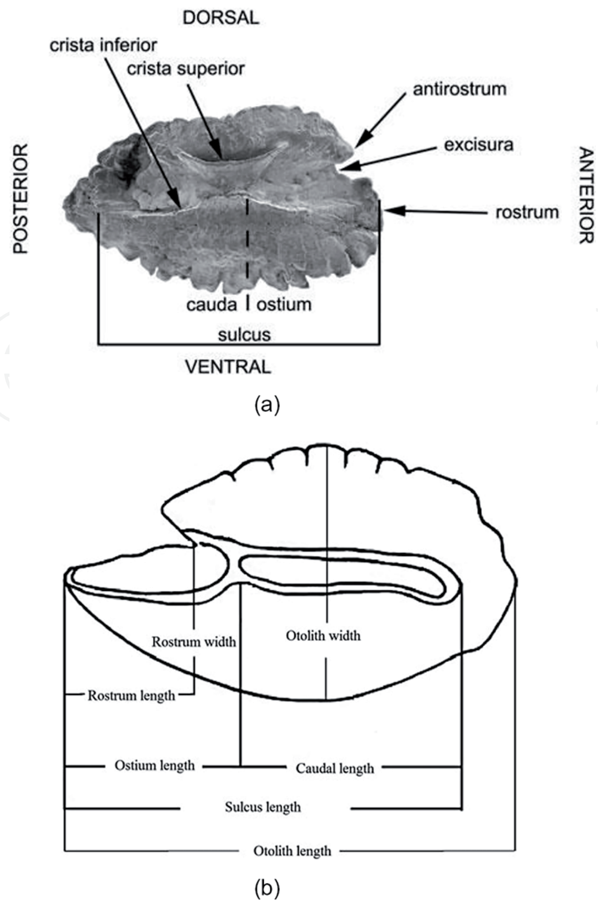


Figure 8.
a. Mesial surface of the left otolith of H. harid *showing its various biometric features. b. Schemeatic diagram of the inner surface of saccular otoliths of a parrotfish showing biometric measurements.*

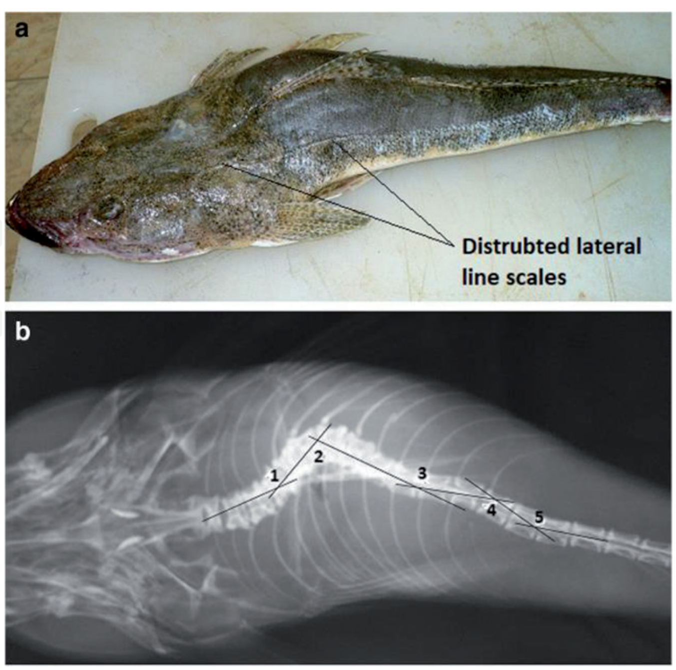


Figure 9.
Platycephalus indicus, 237 mm TL, 231 mm SL, showing scoliosis. a, whole specimen, with deformed lateral line; b, radiograph of Platycephalus indicus, 237 mm TL, 231 mm SL showing skeletal deformity. Numbers 1–5, refers to the angles of curvatures.

from different habitats (Mediterranean Sea and Red Sea, Egypt), Since these characters are sensitive to any environmental changes. The same length range of specimens from both locations was used in morphometric measurements where the resemblance between the sizes of both populations could cause uncertainty with the allometry parameters and it is necessary to avoid size effects. The body width can be strongly influenced by sexual maturation and fullness of stomach as well as the inflating of the body especially for puffer fish that can inflate itself (**Figure 10**).

Using hard parts as spines; the spines are also used in comparison and identification depending on its biometrics and structure. Jawad et al. [13] described structure of the pectoral fins spine of 4 catfish species *Heterobranchus longifilis*, *Clarias gariepinus*, *Chrysichthys auratus*, *Synodontis schall* and *Synodontis serratus* from the River Nile at Asyut City and Lake Nasser, Egypt respectively. The species examined showed variation in the shape of the spines and other biometrics that could be differed among species (**Figures 11** and **12**).

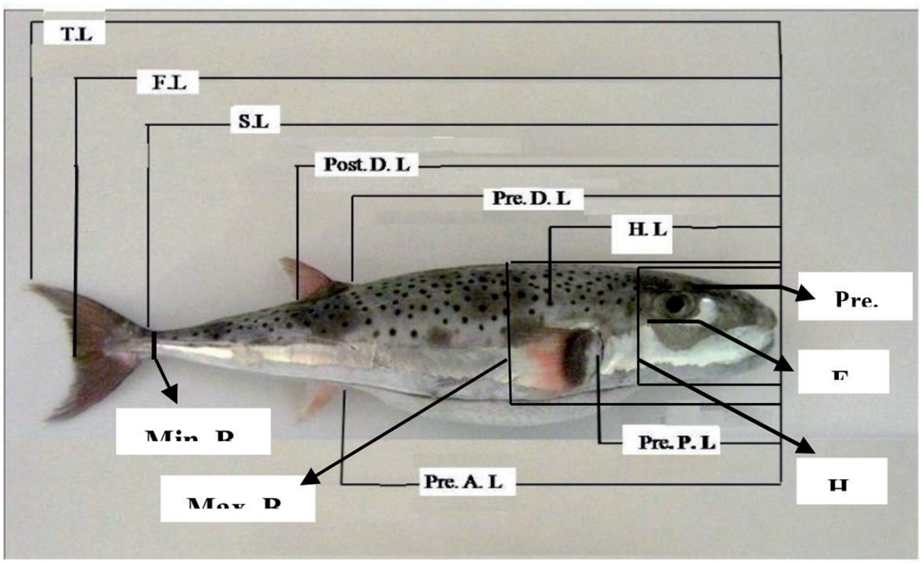


Figure 10.
Lagocephalus sceleratus *showing morphometric measurements.*

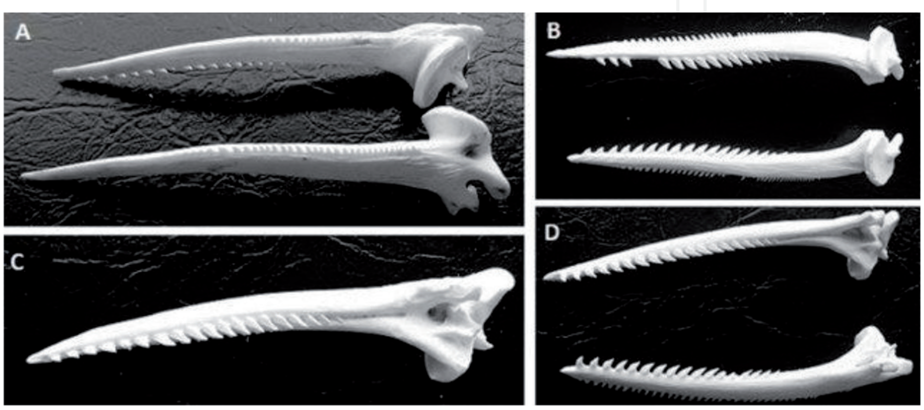


Figure 11.
Left and right pectoral fin spine of Synodontis schall*, 400 mm TL (A, C) and* Synodontis serratus*, 400 mm TL (B, D) showing dorsal and ventral sides.*

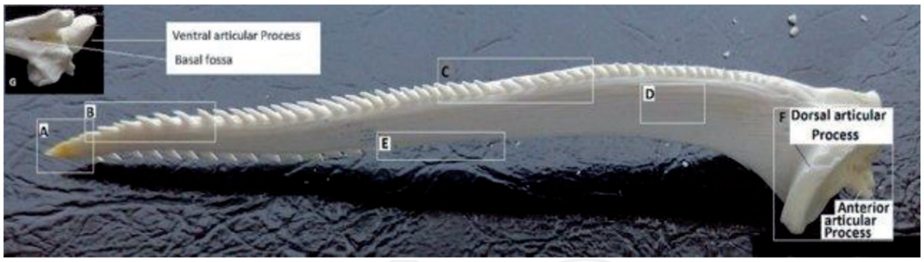


Figure 12.
The enlarged left pectoral-fin spine of S. serratus *(A. anterior distal serrae, B. anterior ridge, C. anterior dentations, D. shaft surface texture of ridges and grooves, E. posterior dentations.*

2.5 As identification and conservatory tools

Biometric methods have therefore been developed to recognize animals based on physical characteristics or behavioral signs. Some of these methods have been used for some time for reliable identification of humans. An animal biometric identifier is any measurable, robust and distinctive physical, anatomical or molecular trait that can be used to uniquely identify or verify the claimed identity of an animal [2].

Sharawy et al. [32] have identified some Penaeid shrimps from Mediterranean, Egypt by different methods. Among them, the authors have applied the biometrics firstly to be correct way to advanced methods or following one. Three penaeid species *Penaeus semisulcatus*, *Metapenaeus monoceros* and *Trachypenaeus curvirostris*. Moreover, they provided the fundamental parameters (**Figures 13a** and **b**) which are important for fisheries management of the currently studied shrimp species. Hence, the conservation resulted after morphological identification has been applied for these species and others others particularly the commercial ones.

2.5.1 Photographing and visual monitoring

The Photographic identification is among biometric methods, it has been used since the 1970s to identify aquatic animals such as dolphins and whales [41]. Individual bottlenose dolphins can be identified by comparing photographs of their fins, which display curves, notches, nicks and tears (**Figure 14**). Whales can be distinguished by the callosity patterns on their heads [42].

The photographing and its treatments using technology used in wide range particularly for wild animals. The most obvious biometric marker is the coat pattern of animals which often appears on major body parts as colourations of either fur, feathers, skin or scales. For example, zebras and tigers can be identified from their stripes; cheetahs and African penguins carry unique spot patterns and snakes have colored rings [28]. From another side, the photographing may face some problem. Problems may occur in the field in different light settings or surroundings, but new techniques including digital photography and video filming have reduced these difficulties. Digital images can also be manipulated to make recognition easier. The method is cheap and at its simplest needs no more than paper and pencil. In addition, observations can be made at a distance, reducing the risk of stress and altered behavior.

2.6 As an indicator of growth

This is another application for morphometric characteristics used to evaluate the growth of species. This was applied on blue swimming crab *Portunus segnis* from the

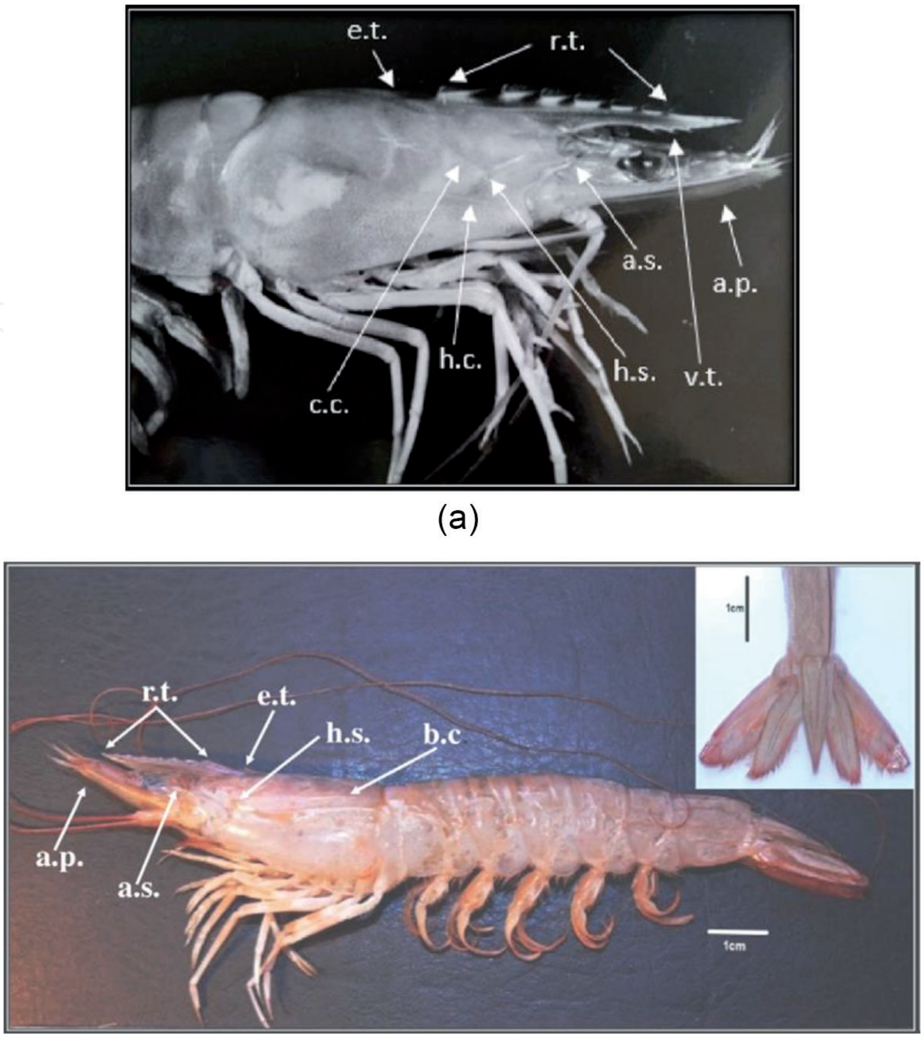


Figure 13.
a. Carapace of green tiger prawn P. semisulcatus shows antennal spine (a.s.), antennal peduncle (a.p.), cervical crest (c.c.), epigastric tooth (e.t.), hepatic crest (h.c.), hepatic spine (h.s.), rostal teeth (r.t.) and ventral teeth (v.t.). b. Speckled shrimp M. monoceros shows the antennal peduncle (a.p.), the antennal spine (a.s.), branchiocardiac crest (b.c.), epigastric tooth (e.t.), hepatic spine (h.s.) and rostal teeth (r.t.) together with its dorsal view of telson and tail fan [32].

Figure 14.
Dorsal fins of bottlenose dolphins displaying unique permanent characteristics used for their identification (© 2007 Dolphin Research Center, 58901 Overseas Highway, Grassy Key, FL 33050-6019, USA. http://www.dolphins.org/marineed_photoid.php).

Gulf of Gabes [43]. The carapace width/length- weight relationship was studied in both sexes of crab (**Figure 15**). The exponential values (b) for the carapace width-total weight relationship were distinct between the sexes with a positive growth

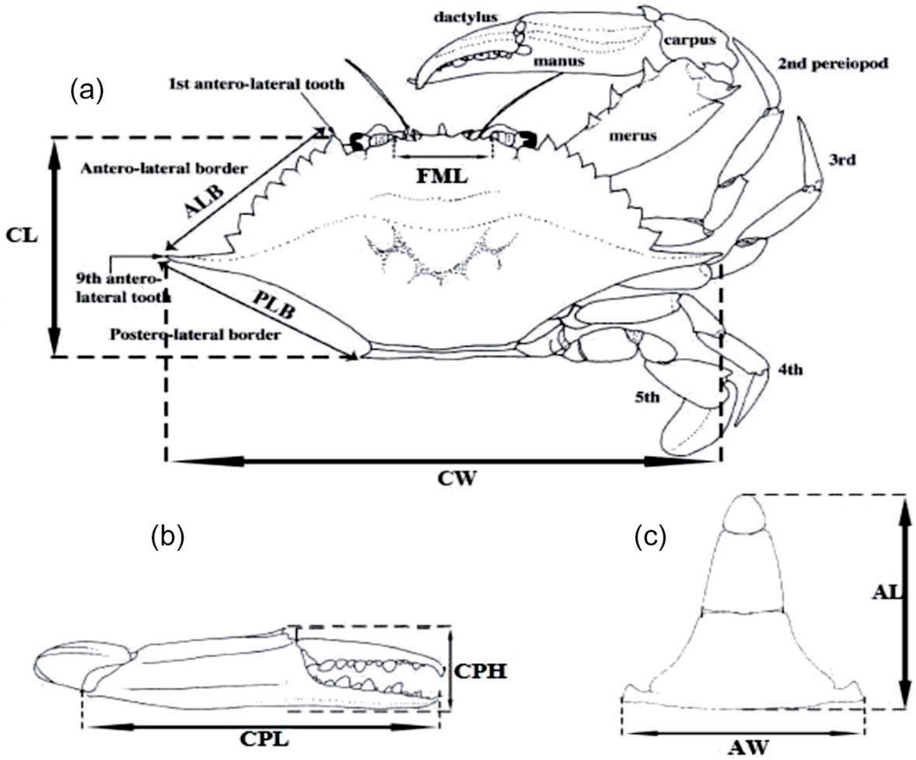


Figure 15.
The morphometric measurements in P. segnis. *a, carapace in dorsal view; b, chela; c, abdomen; CW: Carapace width; CL: Carapace length; ALB: Antero-lateral border; PLB: Postero-lateral border; FML: Frontal margin length; CPL: Chelar propodus length; CPH: Chelar propodus height; AL: Abdomen length; AW: Abdomen width.*

pattern in weight for males, and a negative allometric pattern identified for females. Males were significantly larger and heavier than females, the expected pattern to many crabs.

2.7 Characterization of parasites

The application of the morphology and morphometric was also used to characterize the parasites. It was applied on *Proenenterum* sp. (family: Lepocreadiidae), a new digenetic trematode infecting the pyloric portion of the stomach and the middle part of the intestine of the common sea bream *Pagrus pagrus* fish, they were described by light and scanning electron microscopy for the first time from the coasts of Gulf of Suez and Hurghada city of the Red Sea in Egypt [44]. *Proenenterum* species is characterized by its smaller dimensions and the presence of a large ventral sucker, two lobed testes (**Figure 16**).

2.8 Guidance for computer-cheaper analysis

The biometrics now play an important role in computer analysis of the pictures. The retinal vascular pattern is another biometric trait in animals. The retinal vessels seem to like branching patterns, which are present from birth and do not change during the animal's life. The blood vessels in the eye of each individual can be detected using a retinal scanner. This pattern can be recorded with a hand-held device about the size of a video camera. Some devices can also measure GPS coordinates that used when marking cattle and can be compared to nose-prints. The method is also relatively cheap. Retinal imaging and nose-prints of sheep and cattle were compared by

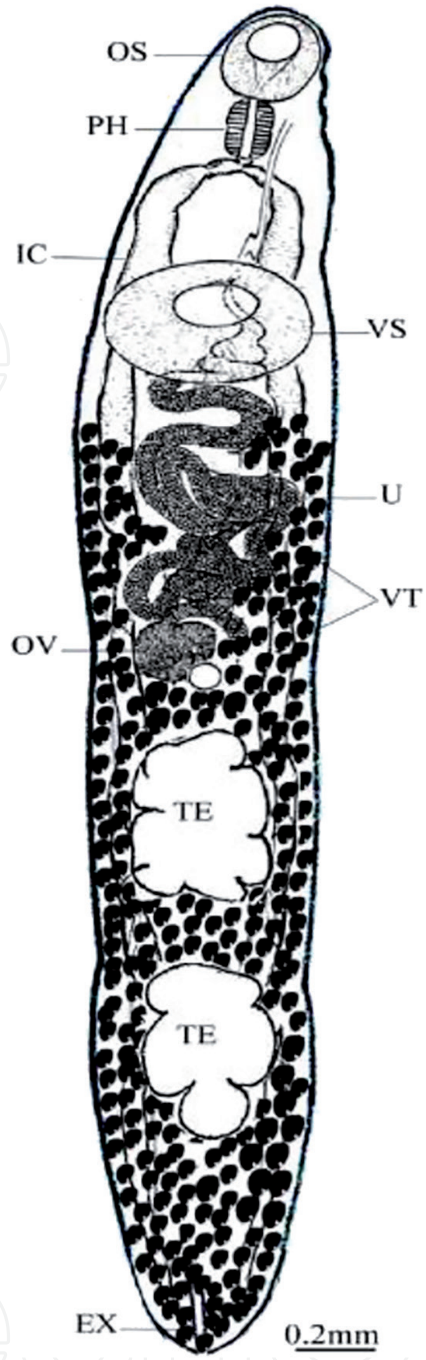


Figure 16.
Line diagram of adult Proenenterum *sp. oral sucker (OS), ventral sucker (VS), pharynx (PH), intestinal caeca (IC), testis (TE), ovary (OV), uterus (U), vitelline follicles (VT), excretory tube (Ex).*

Rusk et al. [45]. However, the nose-prints are a quicker method than retinal scanning, but retinal scans are easy to analyze for inexperienced operators [46]. Computer software for the analysis of digital pictures from both retinal scana and nose-prints makes analysis faster, cheaper and more reliable.

2.9 Movement patterns analysis

The movement pattern is sometimes used as identifier for aquatic animals by analyzing their movement patterns using a tri-axial accelerometry device [47]. By measuring the movements of animals in three dimensions, their movement patterns can be stored and these can be used to diagnose aberrant behavioral patterns, such as those associated with infections. Accelometery may have the potential to be a powerful tool to produce maps for conservation purposes, where animal movements can be plotted.

2.10 Imaging-computerizing treatments

This trend was mentioned by Kumar et al. [48] through recognition systems and this contains different points. For example, the low-Cost Cattle Recognition System Using Multimedia Wireless Network, this system is proposed for verification of individual cattle based on its muzzle point image pattern using wireless multimedia networks. The images are captured using a 20-megapixel camera (system configuration: 14.48 centimeters (5.7-inch) IPS capacitive touchscreen with 1440 × 720 pixels resolution and 283 ppi pixel density, 4GB RAM) and transferred them to the server of cattle recognition using Wi-Fi communication technology. The system performs the image pre-processing on the captured muzzle point image of individual cattle. It mitigates and filter the noise from the captured images and increases the quality [48]. This system could be applied also on the aquatic animals.

The system takes the visual biometric feature characteristics such as coat pattern, body coat pattern, and spot point pattern, and other visual features of species or individual animal. The major issue and challenges of visual animal biometrics-based recognition systems are demonstrated as follows.

- How do species or individual animal gets its body coat pattern? [27].
- What type of suitable algorithms and animal biometrics recognition systems or frameworks is available to compute the visual features from the body coat pattern of species? [27, 28].
- Can detection and representation of visual feature of body pattern of species be possible in their habitats? [28].
- How visual animal biometrics-based recognition and framework can monitor animal population? [28].
- How visual animal biometrics-based recognition system generates unique templates from stored visual biometric feature of species? [27].

3. The considerations that should be taken during the biometric implementation and examples

- Knowing the variations between different organisms and different shapes, therefore should have measurements according to kind of organisms, (Shark, rays, bony fish, crabs, etc).
- It will be better to take the biometric measurements for fresh samples to avoid any error due to preservation or damage in samples. In case of formalin preservation, some changes may happen especially in coloration. So, the more measurements are preferred to be considered.

- In case of comparative study between different habitats, it is preferred to fix the measurements and inputs like length range to avoid bias due to changes in ecological conditions.
- In case of applying biometrics on the internal parts or using scanning techniques, the accuracy, resolution and magnification should be considered.
- In case of using some tools like sensors, it should be easily presented to a sensor and converted into a quantifiable format, should not subjected to changes over time and should differ in the patterns among the general population, the higher the degree of distinctiveness, the more unique is an identifier.
- Biometric methods should not cause pain and do not alter the appearance of the animal, having no effect on the behavior and survivability of the animals, except in some necessary as repeated capture and/or handling.
- In case of visual patterns methods, some species have external characteristics as color, spots, rings, that are easy to recognize and that are specific for each individual. These patterns can be used by photographing using high resolution of digital camera to avoid the problems that may occur in the field in different light settings or surroundings.
- Many common marking procedures also involve tissue damage and therefore cause pain, such as branding (heat, cold or chemicals), tattooing, toe clipping, ear notching and tagging.
- Wearing a mark may alter the animal's appearance, social interaction, other behaviors and ultimately its survival.
- In visual animal biometrics for computer treatment purposes, various issues and challenges lie in coping with unconstrained environment such as variable lighting, partial occlusion of animal body, and extr.... the captured data sets, images, videos are required to train various computer vision models, framework, and methods.

4. General examples of different aquatic animals and their measurements

The followings are summarized guide for general outer measurements and descriptions that could be taken for various forms and examples of some aquatic organisms including crustaceans, fishes, reptiles and some marine mammals (**Figures 17–24**).

5. Conclusion

In conclusion, the biometrics in organisms (Morphometric, meristics and description) have widely importance used in various fields' "taxonomy, species identifications, monitoring of pollution, species abnormalities, comparison, indicator of environmental changes, growth variation, feeding behavior, ecological strategies, population parameters and water quality of aquaculture operations. The scientists are still applying these measurements even with the presence of advanced techniques

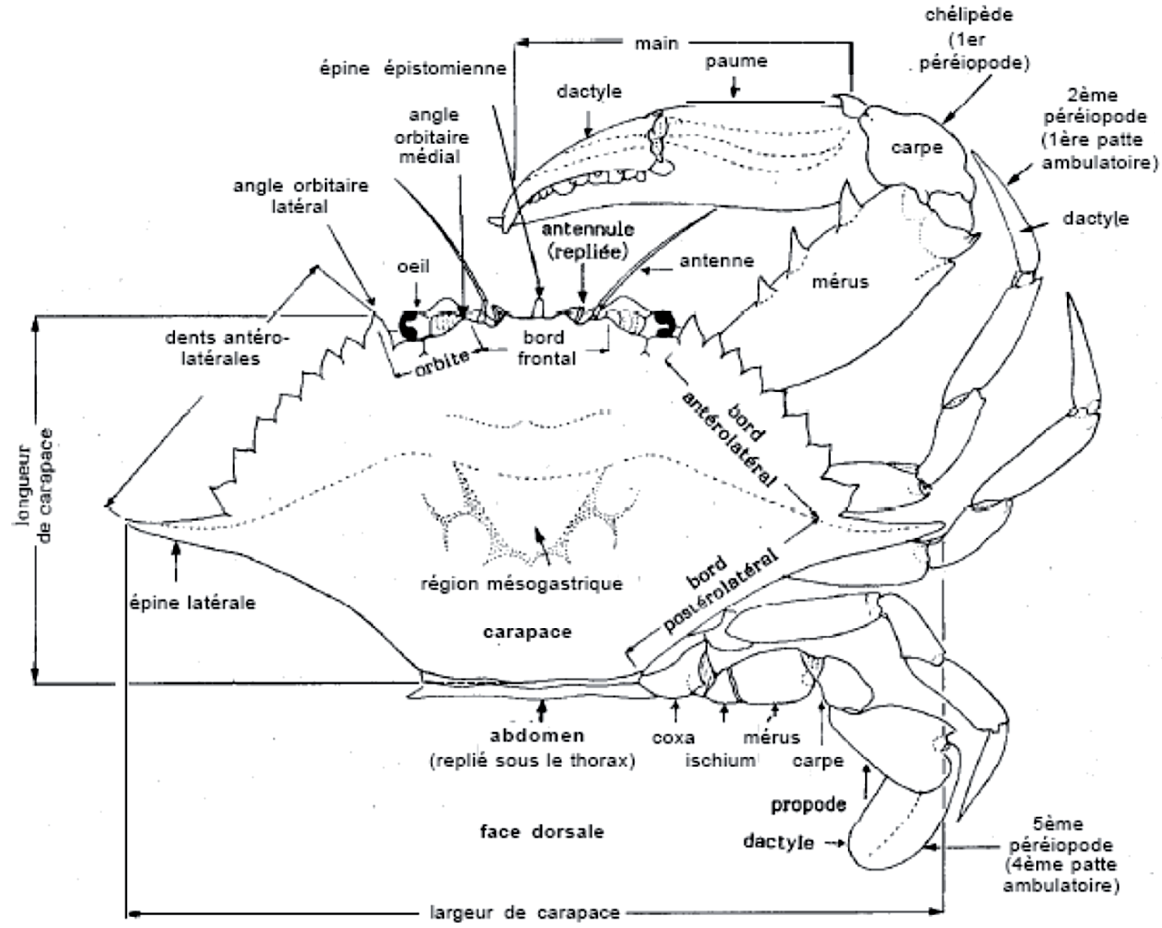


Figure 17.
General morphometric measurement and description of the common form of crabs.

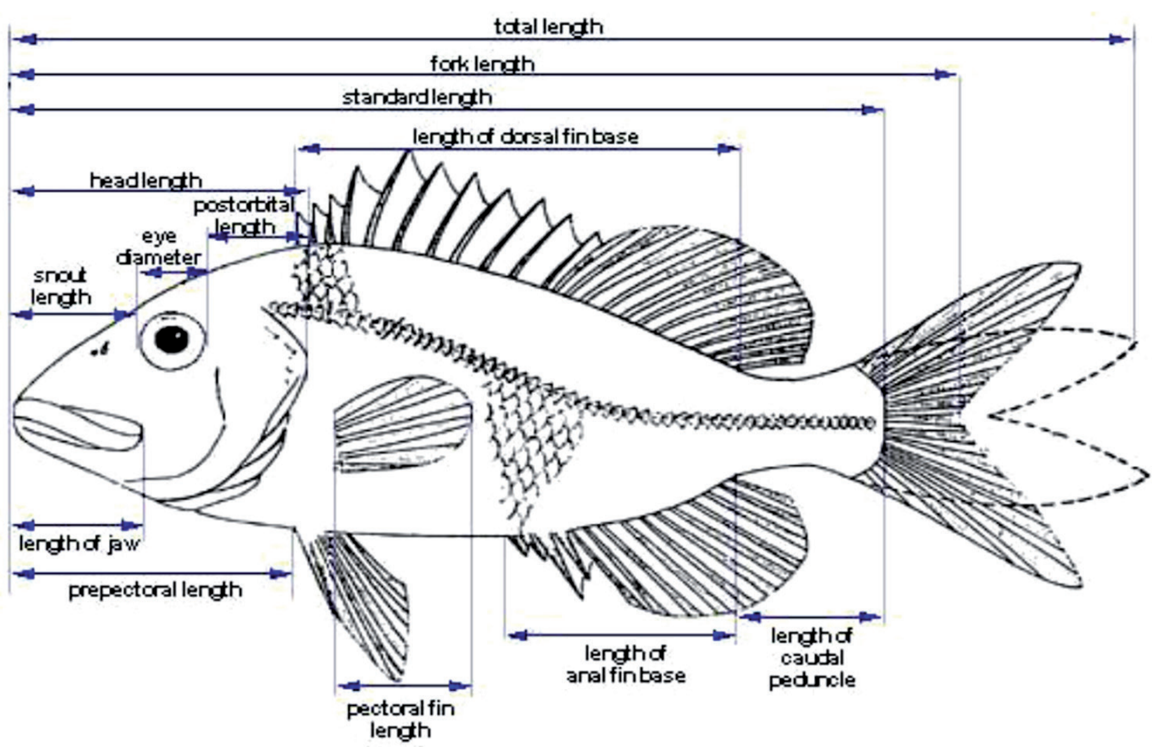


Figure 18.
General morphometric measurement and description of the common form of bony fish.

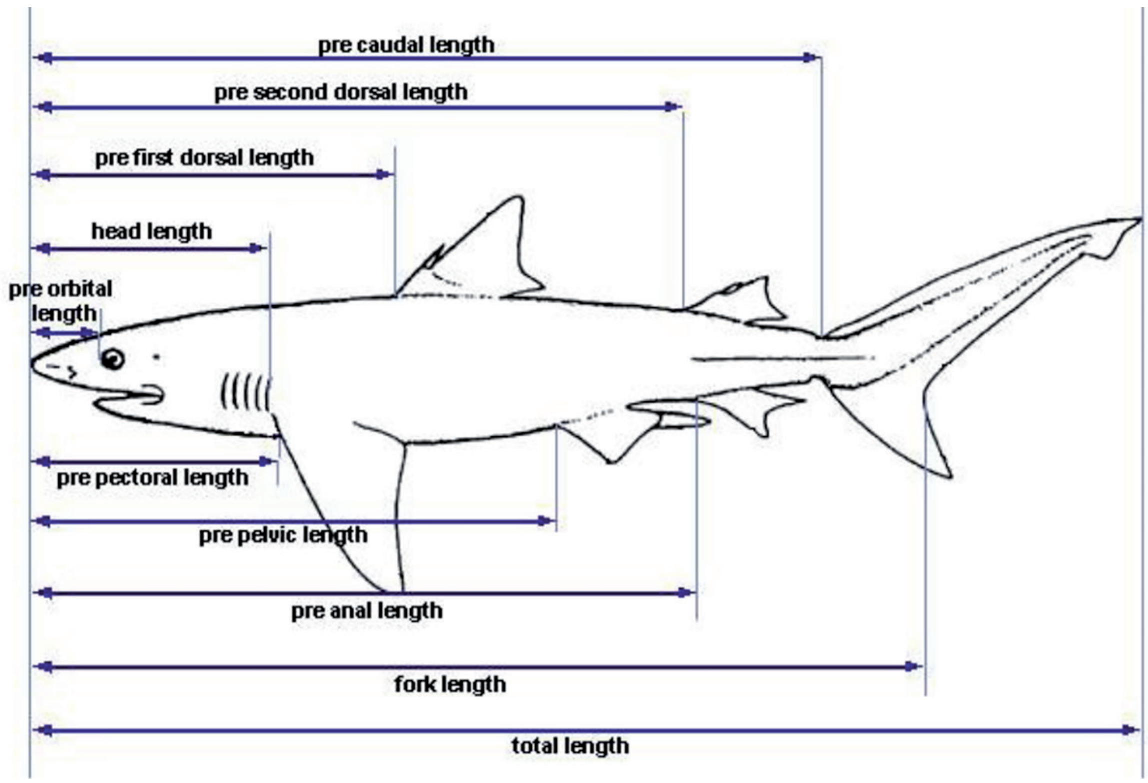


Figure 19.
General morphometric measurement and description of the common form of cartilaginous fish.

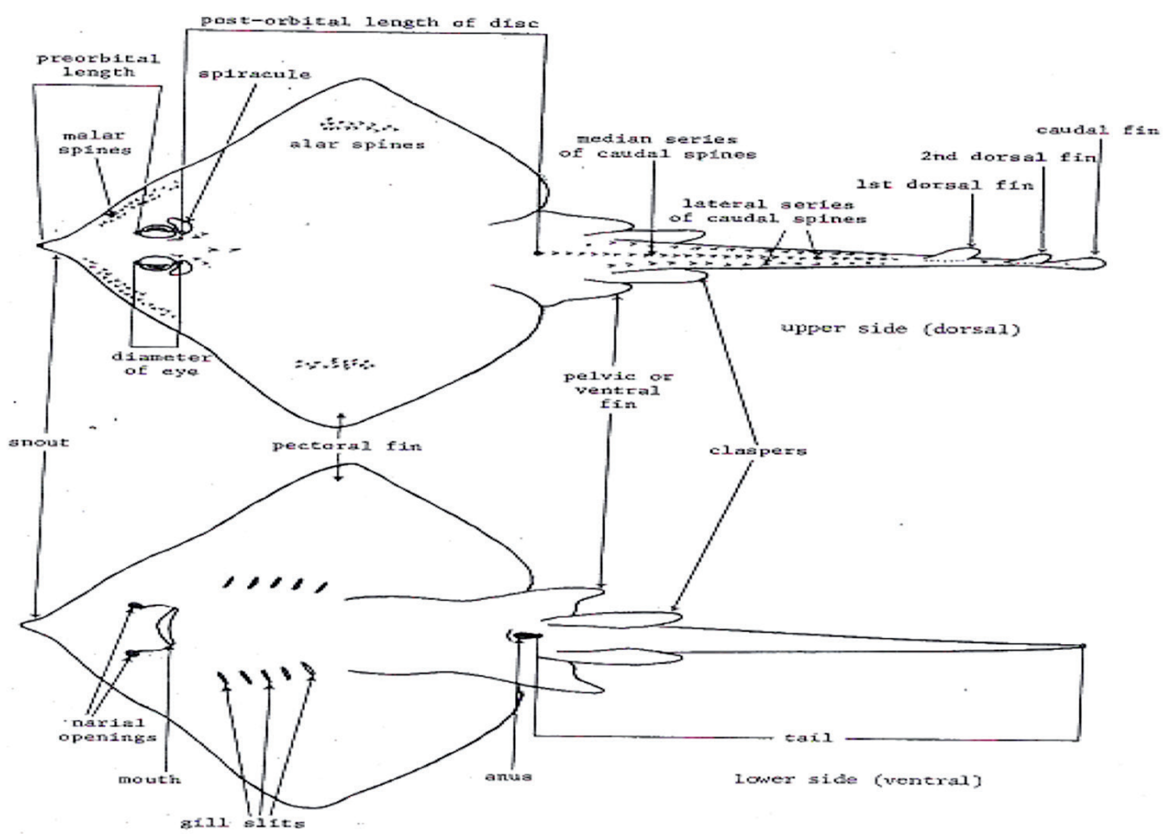


Figure 20.
General morphometric measurement and description of the other form of cartilaginous fish (skates).

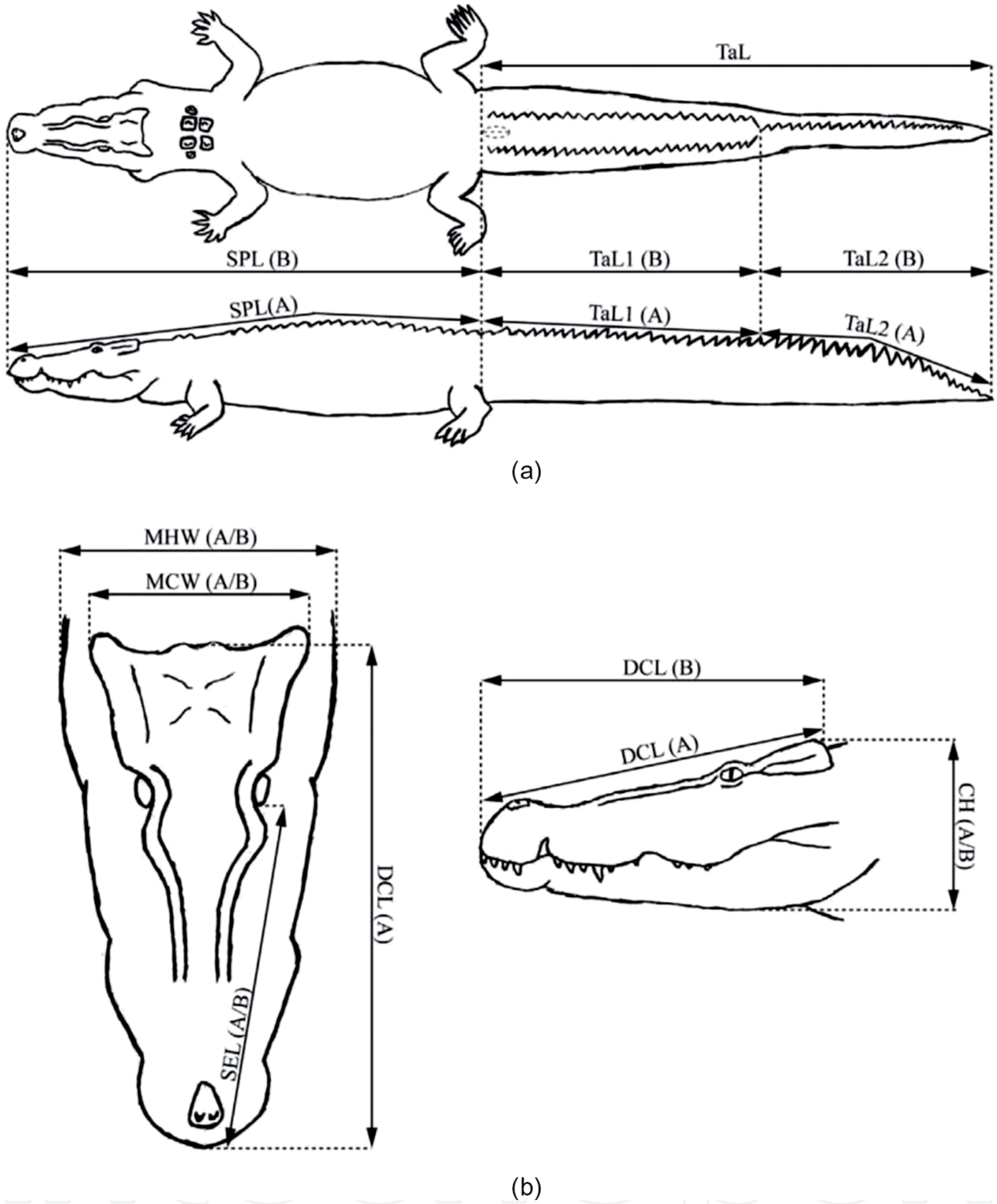


Figure 21.
Top-down and profile diagrams of entire crocodile (a) and head (b) illustrating measurements taken using Method A (A) and Method B (B). DCL = dorsal cranial length; SEL = snout–eye length; MHW = maximum head width; MCW = maximum cranial width; IOW = inter-orbital width; CH = cranial height; SPL = snout–pelvis length; TaL = tail length; TaL1 = anterior tail length; TaL2 = posterior tail length; SPL + TaL1 = snout–scute junction (SSJ); SPL + TaL1 + TaL2 = total length (TL) [49].

because it is the principal knowledge and first guide, low cost, faster and more available tools used. The considerations for the biometric implementation should be taken during the analysis considering the specificity of the quality, preservation status, kind, form of organism and main target of analysis. Its recommended to give more attention to care the biometrics outer/ inner organisms in scientific studies using the advanced techniques, this will be more beneficially together with other modern techniques which required in certain cases for the same purposes.

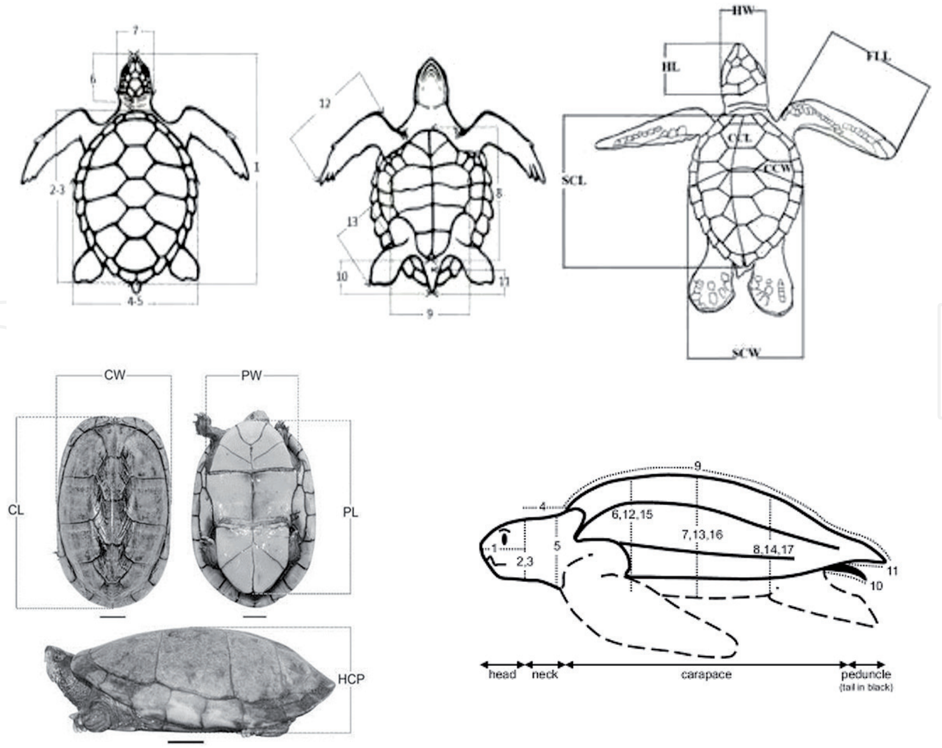
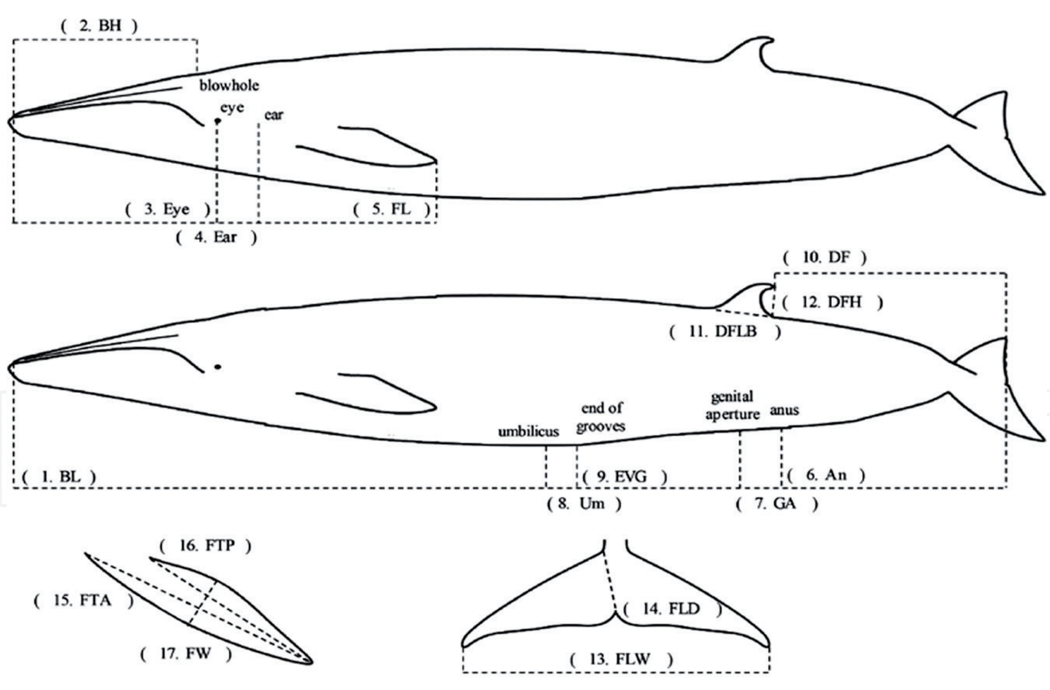


Figure 22.
General morphometric measurement and description of some sea turtles.



1. BL: Tip of snout to notch of flukes
2. BH: Tip of snout to blowhole
3. Eye: Tip of snout to eye
4. Ear: Tip of snout to ear
5. FL: Tip of snout to tip of flipper
6. An: Notch of flukes to anus
7. GA: Notch of flukes to genital aperture
8. Um: Notch of flukes to umblicus
9. EVG: Notch of flukes to end of ventral grooves
10. DF: Notch of flukes to tip of dorsal fin
11. DFLB: Dorsal fin, length at base
12. DFH: Dorsal fin, height
13. FLW: Flukes, width tip to tip
14. FLD: Flukes, depth
15. FTA: Flipper, tip to anterior insertion
16. FTP: Flipper, tip to posterior insertion
17. FW: Flipper, maximum width
18. SKL: Tip of premaxilla to occipital condyle
19. SKW: Greatest width of skull

Figure 23.
Measurement points for the body proportions of Bryde's whales. Measurement points were selected based on the study by Mackintosh and Wheeler [50].

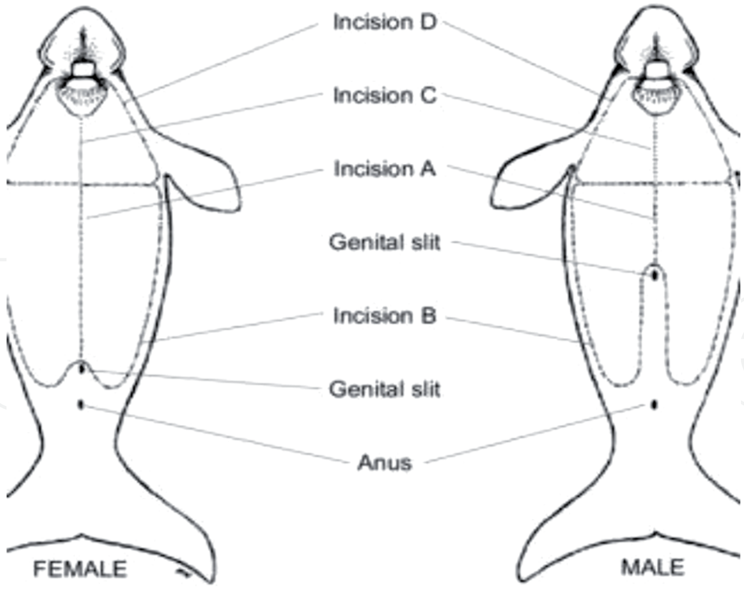


Figure 24.
General morphometric measurement and description of other marine mammals.

Author details

Mahmoud M.S. Farrag
Faculty of Science, Al-Azhar University, Assiut, Egypt

*Address all correspondence to: m_mahrousfarrag@yahoo.com and mahrousfarrag42@azhar.edu.eg

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