Abstract
Neoplasia are growth disturbances characterized by excessive, abnormal proliferation of cells, independent of normal-regulating mechanisms of the animal and persisting after termination of the stimulus that initiated growth. Over lasts years there has been an increase in research into tumors of invertebrates. In cephalopods, reports on the incidence of the tumors or neoplasia are scarce. They have been described as hard compact and homogeneous nodules of connective tissue located in the mantle or at the base of suckers. The aetiological origin of tumors observed in cephalopods is unknown, but it could be related to aquarium maintenance. Other injurious agents, including infectious (virus, bacteria, or parasites) and xenobiotics, may also have produced the lesions. In occasions inflammatory processes have been associated with tumors with severe oedema associated. Inflammation is part of the biological response to body tissues to harmful stimuli such as pathogens, damaged cells or effect of xenobiotics. The inflammatory focus is characterized by exudation with interstitial fluid changes and hemocytic migration. Some inflammatory lesions include fibrosis and necrotic cells in the affected area, with loss of histological features and even organ architecture. All these changes have been observed in cephalopods in inflammatory reactions originated by infection with different pathogens. The chapter covers a selection of the reported cases of disorders related to neoplasia and inflammation.

Keywords
Neoplasia • Tumors • Inflammation • Haemocytic infiltration • Aedema

15.1 Introduction
Neoplasia are growth disturbances characterized by excessive, abnormal proliferation of cells, independent of normal-regulating mechanisms of the animal and persisting after termination of the stimulus that initiated growth (Sparks 1985). Similarly, tumors are ectopic masses of tissue formed by due to an abnormal cell proliferation. Over lasts years there has been an increase in research into tumors of invertebrates, since previously it was thought that tumors only occurred in vertebrates and invertebrates were not susceptible to developing neoplasia (Engel 1930). Nowadays the research in the area has increased and increasing number of tumors has been...
detected in these organisms. Thus, histological and molecular research has provided a better understanding of the nature of these abnormal growths (Tascetta and Ottaviani 2014). In marine invertebrates, different types of tumors have been described, namely those emerged spontaneously, those due to hereditary phenomena, and those due to a wide range of environmental factors. Among those induced by environmental factors, different injurious agents including chemical toxins, physical stress, biological infections and potential carcinogenic substances, may produce that lesions (Hanlon and Forsythe 1990a). In molluscs, tumors, tumor-like growths or neoplasia have been described in gastropods, bivalves, and in some cases in cephalopods. In bivalves, sarcomas of hematopoietic origin such as disseminated neoplasia, or gonad neoplasia have been identified as causative of important mortalities (Carballal et al. 2015). Very few reports have been published in cephalopods.

Other disorder commonly observed in cephalopods is inflammation. It is part of the biological response to body tissues to harmful stimuli such as pathogens, damaged cells, or effect of xenobiotics. Inflammation is a protective response with a function of eliminates the initial cause of the cell injury, clear out necrotic cells and tissues damaged and initiate tissue repair. The description of the tissue modifications occurred in relation to infectious or non-infectious agents by histopathological analysis is essential for an accurate diagnosis of the disease.

15.2 Neoplasia and Tumors

In cephalopods, the incidence of the tumors or neoplasia is extremely low. In 1951 Jullien and Jullien (1951) reported cuttlefish with hard compact and homogeneous whitish nodules of connective tissue with loss of normal stratified appearance and highly vascularized at the periphery. In some cases, haemocytic infiltration is observed between the connective tissue and muscular fibers (Wautier and Wautier 1955). Similar nodules were also observed in Octopus vulgaris (Figs. 15.1 and 15.2). Nigmatullin provided morphological data on tumors observed in O. vulgaris off the northwest coast of Africa with a prevalence of 1.6% of caught octopus. Pascual et al. (2006) described lesions characterized by consistent swelling of smooth surface nodules located at the sucker’s base and mantle of Octopus hubbsorum (Figs. 15.3 and 15.4). At histological level, the lesions appear as mass proliferations of dense fibrous tissue between the dermis and muscle layers (Fig. 15.4a–c). Muscular tissue surrounding the lesions was degenerated and necrotic foci were observed (Figs. 15.2 and 15.4). The aetiological origin of tumors observed in cephalopods is unknown, especially in those observed in wild individual. However, different authors suggest that it could be the result of traumatic episodes related to aquarium maintenance (Hanlon and Forsythe 1990b). Other injurious agents, including infectious (virus, bacteria or parasites) and xenobiotics, may also have produced the lesions (Hanlon and Forsythe 1990a).

15.3 Inflammation

Histologically haemocytic infiltration with eosinophilic staining is observed in the intercellular space of a tissue with inflammation. The inflammatory focus is characterized by exudation with interstitial fluid changes and hemocytic migration. Some inflammatory lesions include fibrosis and necrotic cells in the affected area, with loss of histological features and even organ architecture. All this changes have been observed in cephalopods in inflammatory reactions originated by bacteria, parasites such as the coccidian Aggregata or metazoans such as Anisakis infections (Fig. 15.5). In occasions, inflammatory processes have been associated with tumors with severe oedema associated. Hanlon and Forsythe (1990a) described the presence of severe edema of the mantle and arms of O. joubini and O. maya, where epidermis and dermis are separated from the underlying muscle layers, or even the entire dermis of the mantle was separated from the muscle layers by a watery, almost gelatinous, layer of fluid. This condition was always fatal within 48 h. Similar lesions associated to inflammation process have been observed in Octopus vulgaris maintained for long period in aquarium installations also with fatal result within 48–72 h (pers. obs.) (Fig. 15.6).
Fig. 15.2 Histological sections of nodules in *O. vulgaris* (a–g). 

- **a–e** Detail of mass proliferations of dense fibrous tissue between the dermis and muscle layers.
- **f–g** Detail of necrotic foci also observed in **a** and **b**. 

*Scale bars*:
- a, d, 200 µm; b, f, g, 100 µm; c, e, 500 µm
Fig. 15.3 Macroscopic aspect of nodules located at the sucker’s base (a) and mantle (b) of Octopus hubbsorum

Fig. 15.4 Histological sections of nodules of O. hubbsorum. (a–c) Mass proliferations of dense fibrous tissue between the dermis and muscle layers. Scale bars a, 1 mm; b, c, 500 µm
15.4 Concluding Remarks

While the study and identification of neoplasia has been increased in invertebrates and specifically in molluscs in the last years, the incidence of tumors in cephalopods is extremely low. Similarly occurs with histopathological descriptions of biological response or reactive processes of body tissues to harmful stimuli such as inflammatory reactions. The causes and effects of these disorders are not well studied. However, it is known that at least some of them could be the result of traumatic episodes, both in the wild or related to aquarium maintenance. Therefore, in the context of animal welfare, further research is needed in order to identify and to analyze the progress of those processes to avoid fatal results and to provide the best welfare conditions to the animals in captivity.

Fig. 15.5 Inflammatory focus in the mantle of *O. vulgaris* showing exudation with interstitial fluid and hemocytic migration (a–b). Fibrosis and necrotic cells is observed in the affected area (b), with loss of histological features (epithelium) (c–d) and even organ architecture (a). *Scale bars* a, 500 µm; b, 200 µm; c, d, 100 µm.

Fig. 15.6 Aedema in the arm of *O. vulgaris* maintained for long period in aquarium installations (a–b). a Macroscopic aspect of aedema focus at arm level characterized by exudation with interstitial fluid accumulation and hemocytic migration. b Histological detail showing the epidermis and dermis separated from the underlying muscle layers, by a watery, almost gelatinous, layer of fluid close to the sucker. *Scale bar* b, 1 mm.
References

Carballal MJ, Barber BJ, Iglesias D, Villalba A (2015) Neoplastic diseases of marine bivalves. J Invert Pathol 131:83–106
Engel CS (1930) Warum erkraken wirbellose tiere nicht an krebs? Ztschr F Krebsforsch 32:531–543
Hanlon RT, Forsythe JW (1990a) Diseases of Mollusca: Cephalopoda. Structural abnormalities and neoplasia. In: Kinne O (ed) Diseases of marine animals, vol III. Biologische Anstalt Helgoland, Hamburg, pp 47–227
Hanlon RT, Forsythe JW (1990b) Diseases of Mollusca: Cephalopoda. Diseases caused by protists and metazoans. In: Kinne O (ed) Diseases of marine animals, vol III. Biologische Anstalt Helgoland, Hamburg, pp 47–227
Jullien A, Jullien AP (1951) Sur un type de tumeur non provoquée expérimentalement et observée chez la Seiche. Acad Sci Paris 210:608–610
Pascual S, Rocha A, Guerra A (2006) Gross lesions in the Hubb octopus Octopus hubbsorum. Mar Biol Res 2:420–423
Sparks AK (1985) Synopsis of invertebrate pathology exclusive of insects. Elsevier, Amsterdam
Tascedda F, Ottaviani E (2014) Tumors in invertebrates. Int Sci J 11:197–203
Wautier V, Wautier J (1955) Le cancer et les invertébrés, 1ère partie: réactions tumorales naturelles. Bull Mens Soc linnéde Lyon 3:76–96

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