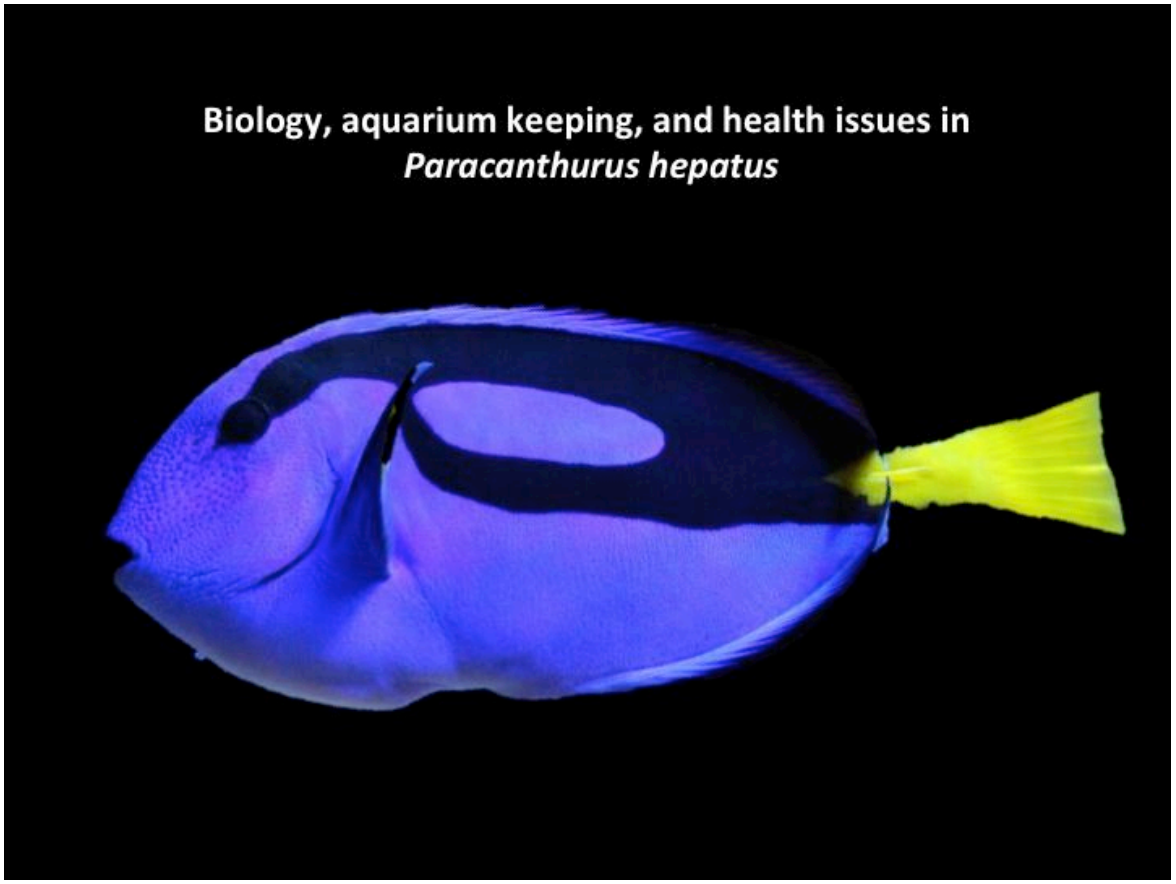

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General Biology of the family Acanthuridae

Surgeons and tangs are characterized by a high profile and laterally compressed oval bodies. The main characteristic of this family is the presence of a sharp, ”scalpel-like” erectile spine on the caudal peduncle that is usually used for defence and inter-territorial defence. Many species have colours that can emphasize this spine, probably facilitating intraspecific communication.

Scales usually end in a small protuberance giving a rough feeling to the skin.

Most of the species belonging to this family are herbivorous and usually feed on algae that are abundant on the shallow reef.

The family is represented by six genera (*Acanthurus, Ctenochaetus, Naso, Paracanthurus, Prionurus, and Zebrasoma*), which can be distinguished by the shape of teeth, dorsal spines, and number and shape of caudal peduncle spines. All these species are distributed exclusively in the tropics and most of them in the Indo-Pacific.

Most of these species do not have a permanent dichromatism, but they usually show temporary colour differences during courtship and spawning. Usually the male presents a darker colour.

Regarding the spawning season, scientific data reported that Acanthurids usually have a spawning peak in late winter and early spring, and the effects of lunar cycles on reproduction have been suggested by many authors.

Surgeonfish are pelagic spawners and produce small pelagic eggs close to the water surface. Reproduction usually occurs at dusk when diurnal predators are retiring on the reef structure and nocturnal ones are not fully active. At this time, predators are fewer and embryos have higher chances of survival.

Fishes belonging to this family have been observed spawning in pairs (*Zebrasoma*) as well as in groups (*Acanthurus*).

Eggs are spherical, transparent, and positively buoyant, with a diameter ranging between approximately 0.6 and 0.8 mm. Hatching occurs after a short embryonic development (about 20–30 hrs). The prolarvae of less than 2 mm are transparent, with unpigmented eyes and closed digestive tract, and feed on the remaining yolk reserves for the next 48 hours. At this stage, the prolarvae turn into larvae that are better developed and show pigmented eyes and open mouth and anus. Larvae are ready to feed on the great variety of microorganisms that are found in the plankton.

There are only a few rearing reports on surgeonfish, and most of the research has been focused on the yellow tang, *Zebrasoma flavescens*, but to date only a limited number of viable eggs have been produced.

Paracanthurus hepatus

The palette surgeonfish (*Paracanthurus hepatus*) is one of the most traded aquarium fish, especially because of its swimming behaviour and beautifully coloured pattern. The brilliant blue body has a black palette shape and the most striking feature of this species is the bright yellow wedge section in the caudal fin.

This species is distributed in the Indo-Pacific region and can reach lengths of 250–310 mm in the wild and less in aquaria.

Palette surgeonfish require **large tanks**[1] to live comfortably, with several rocks and places to hide as well as plenty of room to swim around. As for all Acanthuridae, a reef aquarium with corals is recommended for better maintenance of the species: juvenile and subadult palette surgeonfish[2] in particular form groups near isolated Pocillopora coral heads in the wild and hide themselves among the branches when alarmed. Their natural environment—seaward, patchy reefs—suggests they are active swimmers, used to currents and clear water.

Tanks should also be **equipped with basic filtration** units, including mechanical, biological, and UV sterilizers as well as heaters or chillers and proper illumination. In this way water chemistry (ammonia, nitrites, and nitrates), temperature, and photoperiod will remain constant and at optimum levels.

Their ethological behaviour with others and with conspecific fish is rather peaceful and tolerant. Keeping individual young fish is not recommended, as the fish become shy and sometime stop feeding. Conversely, other surgeonfishes such as *Acanthurus leucosternon* can exhibit territorial behaviour and can in some cases be dangerous for the quiet juvenile palette.

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[1] Recommended aquarium size starts from 600l, Austrian animal welfare regulation requires min

[2] Juveniles and subadults form the preferred size range of the aquarium trade.

Unlike most other Acanthuridae, palette surgeonfish are omnivorous, with a diet that includes zooplankton and benthic algae. Fish should be **fed several (at least 3) times** a day with small amounts of food including *Artemia* and Mysid shrimps, vegetables (like lettuce), seaweed, and algae. The inclusion of marine-based seaweed food is essential at least 3–4 times a week to strengthen their immune system, reduce aggression, and improve their overall health. Algae or vegetables should be fixed on a rock or on the glass using a glass magnet so that the tang can nibble on the food throughout the day.

Reproduction and larval rearing

P. hepatus has been observed to form spawning aggregations in the wild. In captivity, there have been only a few attempts in the culture of this species. In both cases, large tanks with a school of fish were used. The major obstacle in the culture of this precious species is the transition from endogenous to exogenous feeding by the larvae. The delicate larvae are in fact so small that the traditional prey, like rotifers and *Artemia*, may not be adequate.

The first report on the reproduction and larval rearing of this species was published in 2000 and tested several live prey alternatives to rotifers and *Artemia* as first feed.

The larvae, spawned in a group tank, were fed on different prey, including the tintinnid *Amphorellopsis acuta,* and the naked ciliate, *Euplotes* sp. Larvae survived better when fed *A. acuta*. Gut content analyses revealed the presence of loricae of *A. acuta* in the larvae. Feeding on *Euplotes* sp. by larvae was confirmed using ciliates labelled with fluorescent microspheres. The results strongly suggested that both tintinnids and naked ciliates play important roles as alternative food sources to copepod nauplii by enhancing the survivability of fish larvae, especially those with a smaller mouth.

More recently, in 2012, Chen and collaborators described in detail the successful natural spawning of palette surgeonfish in captivity. Fish were maintained in a very large tank of about 30 m^3 at the NMMBA in Taiwan and they exhibited a lunar periodicity in spawning. Eggs were spherical and with an average diameter of 0.69 mm. Larval rearing was performed in 2000 L PVC tanks. Larvae were initially fed on enriched s-type rotifers and copepod (*Euterpina acutifrons* and *Eucalanus* sp.)

nauplii, followed by copepodites and adult copepods (5/ml). Only one fish reached the juvenile stage at 51 days.

It is clear that **all aquarium-bound palette surgeonfish are collected from the wild**. Therefore, the aquarium keeper should consider that each fish is precious and needs to be cultured with love and attention.

The trade of *Paracanthurus hepatus*

Paracanthurus hepatus sold in aquarium shops are **all wild-caught** and prices remain high because this fish is relatively rare in most of its distribution areas. Wild populations are currently declining but it's still not clear if this decline is caused by habitat destruction or by overfishing of this species for ornamental purposes.

Luckily, *Paracanthurus hepatus* is currently found in numerous marine protected areas. For years the IUNC (International Union for the Conservation of the Nature Council) has checked the population in several countries located in its distribution area.

The fish is exported regularly from Indonesia and less frequently from the Philippines. *P. hepatus* population data from Indonesia or the Philippines as the main trade sources are sparse and the current status is unknown and can only be estimated based on anecdotal reports. Many roving collectors are implicated in the trade. Serious exporters keep the fish for the required time to perform proper sanitary checks and acquire health certificates, which are necessary for shipment.

International Air Transport Association (IATA) is the most important association in the air transport sector, setting the rules for the packaging and transport of animals by plane (IATA-Lar: live animal regulations). Fish such as *Paracanthurus* are packed individually in strong plastic bags with 1/3 clean water and 2/3 oxygen. The bags are put in an insulating styrofoam outer container.

Upon landing, the fish usually undergo a second quarantine and after that can be distributed to local retailers and private tanks.

Paracanthurus hepatus is a delicate species, and easily harmed if incorrectly handled. After shipment, they should be adapted in the importers' new tank and attention to the chemical water conditions in the shipping bags is a must. Small pH or salinity variations can be lethal for the

recently imported fish, since transport stress usually drastically reduces their immune defences. If the acclimation is properly performed, the fish usually start feeding immediately the day after. However, other challenges remain—this species is particularly susceptible to several diseases that are discussed in the following section.

Health issues

Like other marine ornamental fish caught in the wild and kept in captivity, palette surgeonfish can develop health problems related to several factors encountered along the "chain of custody", from capture to aquaria. As explained previously, the journey to the aquarium is long and studded with a lot of stressful events that can severely impair the welfare of the fish, making it prone to several opportunistic diseases. For this reason, its introduction in the confined environment of the aquarium always has to be always carried out with careful acclimation and ensuring a readily available proper diet and suitable environmental parameters.

Furthermore, during its life in the aquarium palette surgeonfish can be affected by several disorders caused by nutritional and environmental factors. These could directly cause disease or trigger infectious and parasitic infections, which are generally the expression of complex relationships among the environment, host, and pathogen determinants.

Among the most frequent disorders encountered by palette surgeonfish in aquaria, Head and Lateral Line Erosion Syndrome (HLLE) or Marine Head and Lateral Line Erosion Syndrome (MHLLE) is a chronic disease developing in marine ornamental fish and in particular in Acanthurids and Pomacentrids. The affected fish displays depigmented erosions on the head, often around eyes, that can progress in large and deep ulcers, and extend along the lateral line. HLLE has been linked to different causes and currently there is not a single and unequivocal etiology. In the past, its occurrence has been correlated to parasitic and viral infections, exposure to metals (i.e., copper), nutritional deficiencies in vitamins A and C, scarce vegetation in the aquarium, poor lighting, high levels of nitrate, use of ozone or UV, and certain kinds of activated carbon (i.e., extruded coconut shell). Whatever the triggering factor, the

syndrome evolves overtly under the influence of stressful factors such as poor water quality, improper diet, and overcrowding. For this reason, treatment of HLLE should rely on the elimination of any potential stressors present in the aquarium environment.

Another common disorder in marine ornamentals is thyroid goiter, a metabolic syndrome due to hyperthyroidism. This disorder was initially thought to be related to nutritional deficiencies due to the administration of frozen food deficient in iodine. However, recently it has been correlated to the presence of high levels of nitrates in the water, a factor that would inhibit the capacity of the thyroid gland to utilize iodide from the tank water, with consequent development of goiter. Furthermore, the ozonation of aquarium water can also cause a reduction in available environmental iodide and is currently included among goitrogenic factors for fish cultured in recirculated marine water systems. As a consequence, in these systems an iodide supplementation through the diet and/or tank water is always advisable.

It is therefore evident that the maintenance of optimal environmental parameters and adherence to nutritional requirements are key factors in reducing the amount of stress and improving the welfare of palette surgeonfish in the aquarium, thereby also reducing its susceptibility to opportunistic pathogens.

In any event, several parasitic, bacterial, and viral diseases could affect the palette surgeonfish during its life in the aquarium. Among parasites, those characterized by a direct life cycle (fish-to-fish transmission without intermediate hosts) are certainly the most important, as they can easily spread in the aquarium population. In particular, the ciliate *Cryptocaryon irritans* is quite common in palette surgeonfish, causing "marine white spot disease". This protozoan finds in the aquarium optimal conditions for its development, replicating on the bottom and presenting a polyphasic life cycle positively regulated by temperatures around 25°C. The obligate parasitic feeding stage (trophont) of *C. irritans* lives encysted in host gills, eyes, and skin epithelia, with the emergence of small white spots visible by the naked eye at these sites. Marine white spot disease may represent a serious disease mainly in juveniles, while in adults the infection shows a cyclic occurrence with less serious consequences in absence of secondary bacterial infections. This parasite has been isolated in several marine species, mainly coral reef fish, and its introduction into the aquaria

should be avoided by appropriate quarantine and health checks. Treatment is mainly aimed at killing the environmental stages, in particular infective stages, by different methods.

Furthermore some helminth ectoparasites, such as the large Capsalid monogenean *Neobenedenia melleni*, can cause skin, fin, and eye infections and spread rapidly in a fish population kept in a confined environment, especially in presence of overcrowding conditions. *N. melleni* is one of the most important monogeneans affecting marine teleosts kept in aquaria and shows low host specificity, as it has been reported in over 100 fish species belonging to different families. Although some marine ornamental fish (i.e., angelfish) are particularly susceptible to capsalid infections, *N. melleni* has been described also in palette surgeonfish.

Among bacterial diseases, vibrioses can be responsible for serious disease and mortality of marine ornamental fish. Several *Vibrio* species (*V. harveyi*, *V. anguillarum*, *V. alginolyticus*, etc.) have been isolated from marine ornamental fish during disease outbreaks. Most of these Gram negative bacteria are commonly found in the marine environment and disease occurs mainly when fish are exposed to these infectious agents in the presence of stress factors such as overcrowding, high temperature, high organic load, and others. Clinical signs of vibriosis include exophthalmia, melanosis, hemorrhages on skin and at the base of fins, corneal opacity, skin ulcers, splenomegaly, and enteritis. In addition to the administration of the proper antimicrobial therapy, the resolution of all the factors that may have contributed to the outbreak of disease is essential in controlling the disease.

Another important bacterial disease that can cause significant health problems in palette surgeonfish is mycobacteriosis, also known as piscine tuberculosis, which is caused by different species of atypical mycobacteria such as *Mycobacterium marinum*, *M. fortuitum*, and *M. chelonae*. These acid-fast bacteria are common in the aquarium environment, where they find the favourable conditions to spread (water recirculation, presence of organic material, overcrowding, etc.). They can cause serious chronic progressive diseases in fish, characterized by systemic granulomatosis. This is often fatal to fish because treatment with antimicrobials can slow the progress of disease but will not completely eliminate infection.

In general, improved knowledge on good management practices for palette surgeonfish kept in aquaria, with specific reference to its environmental, ecological, and nutritional requirements, will go a long way toward preventing disorders and diseases and ensuring high levels of welfare and health during the aquarium life of this fascinating fish.

Conclusions

Palette surgeonfish are beautiful reef fish that should be maintained in large reef tanks. To date, all the traded specimens are collected from the wild and are thus extremely precious: the aquarium keeper should put his/her best knowledge in the care of this beautiful fish. Cares start from buying healthy fish from good retailers, providing the fish with large enough tanks, regular feeding of zooplankton and marine algae and seaweed, and being ready to recognize and treat the most common diseases of this species.

Literature cited

Callan, C.K., Laidley, C.W., Rietfors, M.D.C., Kline, M.D., Martinson, E.W. 2013. Oceanic Institute achieves breakthroughs in culture technology for yellow tang (*Zebrasoma flavescens*). Global Aquaculture Advocate 16 (1):79–81.

Chen, C.-H., P.-J. Meng, K.S. Tew & M-Y. Leu. 2013. Natural spawning and early life history of the palette surgeonfish, *Paracanthurus hepatus* (Linnaeus, 1766) in captivity. The 9th Indo-Pacific Fish Conference, 24–28 June 2013, at Okinawa, Japan.

Claisse, J. T., McTee, S. A., & Parrish, J. D. 2009. Effects of age, size, and density on natural survival for an important coral reef fishery species, yellow tang, *Zebrasoma flavescens*. Coral Reefs, 28 (1):95–105. doi:10.1007/s00338-008-0447-7.

Decostere, A., Hermans, K. & Haesebrouck, F. (2004) Piscine mycobacteriosis: a literature review covering the agent and the disease it causes in fish and humans. Veterinary Microbiology 99:159–166.

Francis-Floyd, R. & Petty, D. (2010) Marine Fish. In BSAVA Manual of Exotic Pets. A foundation manual. 5th Ed. Meredith, A. & Johnson-Delaney, C. (eds), pp. 360–372, John Wiley & Sons, Inc., Gloucester, England.

Noga, E.J. (2010) Fish Disease. Diagnosis and Treatment, 2nd edition, Wiley-Blackwell, Ames, IA, USA.

Stamper, M.A., Kittell, M.M., Patel E.E., & Corwin A.L. (2011) Effects of Full-Stream Carbon Filtration on the Development of Head and Lateral Line Erosion Syndrome (HLLES) in Ocean Surgeon. Journal of Aquatic Animal Health 23:111–116.