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# CIRCADIAN RHYTHMS AND DUAL CAPACITY OF FEEDING ACTIVITY IN FISH-A REVIEW

FittrieMeyllianawatyPratiwy*

**Lecturer, Department of Fisheries, Faculty of Fisheries and Marine Science, UniversitasPadjadjaran, Jl. Raya Sumedang KM 21 Sumedang 45363, Indonesia*
*fittrie.pratiwy@unpad.ac.id*

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ABSTRACT

Such a rhythmic behavioral patterns in fish appeared under influence of biological clock and might driven by biological clock, circadian rhythm. This phenomenon has been studied from several decades ago and showed varied among the research. Under the circadian rhythm experiments with a constant environmental condition, one individual has a possibility to show a free running phenomenon in its feeding activity. Interestingly, in one individual species showed a circadian rhythm longer than 24 hours and shorter than 24 hours. Those fish seemed to have a dual biological clock system and this circadian system may affect the seasonal change of diel feeding activity synchronizing with the change of natural photoperiod. Dualistic feeding pattern might be controlled by two independent oscillators which entrained by light and food.

## Introduction

Most animals, including fish, show daily behavioral rhythms and active either during the day or at night. Such rhythmic behavioral patterns appeared from long-term evolution under influence of cyclic selective forces by the rotation on earth, this biological rhythms related to physiological parameters which is driven by endogenous oscillators within the brain or sensory organs[1], specifically behavioral activity of fish such as feeding and locomotion behavior which is synchronized with the change of this kind of environmental variations[2]. The most important entertaining factors are light-dark cycle and food ability. For example, the biological clock continuous to operate and circadian rhythms persist with their own free-run period, diverging slightly from the environmental cycle to which they are normally synchronized[3].

It has also been suggested that feed utilization could be improved by better understanding circadian feeding behavior [4], [5]Daily rhythms of feeding activity have been found in many species under controlled environmental conditions, such as; silver carp, *Oncorhynchus mykiss*[4]and European sea bass, *Dicentrarchuslabrax*[3].

Eriksson (1978) suggested that such a seasonal inversion in fish activity is controlled by biological clock. Throughout the timemany, studies revealed to determine whether feeding activities of fish are regulated by biological clock (internal circadian oscillator) or not, the feeding activity of fish ussualy recorded under controlled laboratory conditions and within a light-dark (LD) cycle, as well as under constant lightness (LL) or constant darkness (DD) conditions. This paper aim to gather dozens of research about circadian rhtyms of feeding activity in fish and summarize it into a simple understanding based on its development.

## Circadian Rhythm in Fish

Circadian rhythm in behavior and metabolism is a phenomenon in biology about adapting the regular changes of their environment, defined mostly by 24-hour period of earth's rotation relative to the sun[6]. The changes of light and water temperature are the two main synchronizing factors (known as zeitgebers) to entrain biological clocks. Light is transposed into a nocturnal rhythm of melatonin that acts as an internal zeitgeber setting up the phase of individual pacemakers[6]. The circadian system in fish si also similar with general design in vertebrates and invertebrates such as rhtyms of activity, food intake, and other physiological parameters[6]. Variation of rhythm activity in several fish species is shown in Table 1.

Table 1. Light Cycle and Circadian Rhythm in some species

| *Species* | *Light cycle and tau* | *References* | *Notes* |
|---|---|---|---|
| European Sea bass (*Dicentrarachuslabrax*) | LL:21.3-26 h | Boujard et al., 2000 | Group of fish |
| Rainbow trout (*Oncorhynchus mykiss*) | LL: >24 h | Sa´nchez-Va´zquez et-al.,2000 | |
| Rainbow trout (*Oncorhynchus mykiss*) | LL:24.6-26.0 h | Chen an Tabata, 2002 | Under restricted feeding schedule |
| Tench (*Tincatinca*) | LD: 40:40 min: 20.8-28.6 h | Herrero et. al., 2003 | Rhythm detected in half of group of fish |
| Nile tilapia (*Oreochromisniloticus*) | DD: 24.4 h<br>LL: 23.6 h | Pratiwy and Kohbara 2017 | Individual rearing condition |

Luisa Maria et al. 2000

## Dual Capacity of Feeding Actifity

According to Eriksson(1978), feeding profile classified into diurnal, indifferent, and nocturnal feeding activity. Some fish showed more than one feeding profile and could change from one feeding profile to another feeding profile depends on its condition, namely Dual capacity of feeding activity.

Some previous studies reported about dualistic feeding profile in fish such as in Tilapia, although Nile tilapia was firstly described as a diurnal animal, present study in line with previous studies have also reported nocturnal patterns under some condition[7][8][9]. Moreover previous study found that the revelation of phase transients and persistent free-running rhythms suggested that Nile tilapia Oreochromisniloticus has a dual feeding profile when the LD 12:12 cycle was replaced with the constant darkness (LD 0:24) or constant lightness (LD 24:0), this indicated that feeding activity controlled under a biological clock by the endogenous circadian oscillators[10]. This phenomenon also reported feeding rhythms of greater amberjack *Serioladumerili*[2]. This ability to display either diurnal or nocturnal behavior in the same

species is known as dualism, which in fish is related to a flexible circadian system.
As shown in Table 1, some studies revealed in one species showed two periods with difference length, one was longer than 24 hr and another one was shorter than 24 hr. In tilapia, it was occurred when the fish exposed by constant darkness τ=24.4 and switched to constant lightness τ=23.6[10]. Different of circadian period also occurred in other species, such as catfish, the feeding rhythm period one from nine catfish which were exposed under continuous lightness condition (LD 24:0) showed less than 24 h and other were 24 h[11].
Dual feeding rhythm period seemed related with dual capacity of feeding activity which is influenced by the endogenous pacemaker mechanism, which rhythms belongs to the type of system that are capable of self-sustaining oscillator and free-running rhythms persists for many periods. Fish might have two possible mechanisms, as well as in mammals. First, the existence of separate couple light and food oscillators or a single oscillator entrainable by both light and food, one entrained by a Food-entrainable Oscillator (FEO) and the other by a light-entrainable oscillator (LEO) as reported in goldfish and rainbow trout[3]. One of oscillators which entrained by light (LEO) might be located in pineal organ, since the main function of the fish pineal organ is to integrate light information and elaborate messages that will impact on physiology and behavior[12].

## Conclusion

Information obtained from circadian rhythm in fish enables us to identify the influences of environmental changes on a physiological condition of farmed fishes through their expression of appetite. Moreover, circadian rhythm experiments showed that some fish species in one individu have a dual feeding capacity which may controlled by different oscillators. This remarkable variability circadian system in fish also could provide new insights into general biological mechanism and add challenge to study for the better future.

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