Design of mobile and low-cost feeding device for aquaculture feeds

Wenwu Mao1*, Kexin Zhang2*, Dengkui Wang3, Mindong Lin1, Jiafeng Chen1

1 College of Engineering Science and Technology, Shanghai Ocean University, Shanghai, China
2 College of Food Science and Technology, Shanghai Ocean University, Shanghai, China
3 College of Fisheries and Life Science, Shanghai Ocean University, Shanghai, China
*Corresponding author: Wenwu Mao e-mail: wwmao@shou.edu.cn, Kexin Zhang e-mail: 1832407@st.shou.edu.cn

Abstract: Artificial feeding is still widely used by small and medium-sized farmers in aquaculture, which requires a large labor cost and cannot guarantee the feeding efficiency. A mobile, low-cost, simple and practical feeding device for aquaculture feed was designed, including the overall scheme, the design of silo, feeding bucket, feeding mechanism and other mechanical structures. The feeding device can reduce the cost of aquaculture and improve the feeding efficiency.

1. Introduction
The feeding amount, an important factor that affects the effects of pond culture and environmental and ecological benefits, should be flexibly controlled and timely adjusted depending on water quality, weather and eating conditions [1]. A good grasp of the utilization rate of bait can lead to diminished pollution of water bodies [2], reduced cost of aquatic feed, and improved feeding efficiency and aquatic product quality. The insufficient feeding amount cannot contribute to the healthy growth of aquatic products, thereby affecting the economic benefits. The excessive feeding amount may damage the aquaculture water body, thus elevating the manpower and material cost.

Manual feeding is primarily adopted in industrial aquaculture [3]. The traditional feeding method features a low feeding accuracy and a high labor cost. There are issues regarding the deteriorating water environment, multiple potential quality and safety hazards of aquatic products, and the growing contradictions between the development of aquaculture industry and resources and environment [4]. Currently, there are few feeding devices that are movable among multiple culture barrels targeting small and medium-sized aquaculture farmers, and most of them have the disadvantages of high acquisition costs, relatively fixed positions and inconvenient use. In view of the feeding demands of small and medium-sized aquaculture farmers, this paper presents with a movable and cost-effective feeding device that can effectively improve the feeding efficiency.

2. Demand analysis
With a view to handling the issues regarding feeding facing small and medium-sized aquaculture farmers throughout the aquaculture, the author has conducted massive investigations. The feeding
device should be in line with the following basic requirements: (1) the aquaculture feeding device is movable among multiple culture barrels, so as to reduce the operating costs of farmers engaging in industrial aquaculture; (2) from the perspective of the device cost, the structural design of the aquaculture feeding device is as simple as possible to facilitate the processing and maintenance and reduce the maintenance cost, thereby lowering the equipment cost of aquaculture farmers; (3) the aquaculture feeding device can control the feeding amount of aquatic feed to a certain extent, and can achieve quantitative feeding; (4) the aquaculture feeding device is simple to operate.

3. Design of feeding device

The design of the aquaculture feeding device includes the overall plan and the designs of main mechanical structures (e.g., hopper, feeding barrel, screw and feeding mechanism). The mechanical structure comprises the hopper, brackets, guide rails, sliders, motor, spiral stirring rods, feeding barrel, base, adjusting rod, springs, baffle plate, inclined pistons, steel wire ropes, driven rods and movable rods.

The quantitative charging amount of the culture barrel is subject to the relative positions of the slider, the baffle plate and the inclined piston in this device. The height of the hopper relative to the ground can change with the changes in the height of the slider. When the amount of feed is charged to the culture barrel, the motor in the hopper starts to drive its spiral stirring rod to rotate slowly, which can stir the feed and facilitate the blanking. Meanwhile, throughout the feeding process, another motor winds and releases the steel wire rope to control the two sliders to reciprocate along the guide rail and then push the inclined piston to move up and down, thus achieving the quantitative control of feeding amount.

![Fig. 1. Stereogram of the device](image)

The discharge outlet (2) is above the culture barrel (1), and fixed and connected with the feeding barrel (3). The guide rail (6) is fixed with the feeding barrel (3), the slider (5) can slide up and down linearly along the guide rail (6), and the mechanism in the base (14) is a feeding mechanical device. The motor (7) is fixed on the hopper cover (8), and the motor (7) drives the spiral stirring rod (20) to rotate, so that the blanking is smooth and the feed blockage is removed. When the feeding barrel (3) is charged, the motor (7) starts to ensure smooth charging. If the charging amount should be adjusted, the slider (5) should be manually adjusted and the adjusting rod (4) should be rotated to adjust the height of the baffle plate (16). The slider (5) slides up and down in the guide rail (6) to adjust its height. At this time, the height of the hopper (9) can be adjusted through adjusting the bracket (11).
The adjusting rod (4) is fixed in the upper center of the baffle plate (15), and the lower center of the baffle plate (15) is fixed with a screw (16). An internal thread hole matched with the external thread of the threaded rod (16) is turned in the center of the inclined piston (17). The relative height of the baffle plate (15) to the inclined piston (17) can be adjusted through rotating the adjusting rod (4), so as to control the feeding amount. The lower bottom surface of the baffle plate (15) is always adjusted to be equal to the highest point of the opening on the slider (5) relative to the ground, and the baffle plate (15) is used to prevent the feed from continuously flowing into the feeding barrel (3) from the hopper (9), so as to control the charging amount. After the required charging amount is adjusted, the slider (5) is moved downwards to close the feeding barrel (3). The driving rod is fixed on the side wall of the base (14) and is provided with a motor at its central position. The motor is connected with the connecting rod, and the connecting rod (20) is connected with the bottom of the inclined piston (17). When the motor starts to rotate, the connecting rod (20) and the inclined piston (17) form a crank-slider mechanism, which uses hinge transmission to push the piston to move vertically up and down along the inner wall of the feeding barrel. When the motor (22) starts to push the piston to the highest position relative to the ground through the hinge transmission, the motor stops rotating for a short time, so that there is enough time for aquatic feed to be charged from the feeding barrel (3) through the discharge outlet (2).
Fig. 3. Stereoscopic scenograph of hopper of the device

The upper opening of the bracket (11) is matched with the support (25), and the height of the hopper (9) relative to the ground can be adjusted through adjusting the matching angle between the bracket (11) and the support. The motor (7) is fixed on the hopper cover (8), and the motor (7) drives the spiral stirring rod (20) to rotate, so that the blanking is smooth and the feed blockage is removed. The hopper (9) is placed on an annular bracket (10), which is placed on a bracket (11). The support is fixed with the annular bracket (10), and the upper opening of the bracket (11) is matched with the support. The height of the hopper (9) relative to the ground can be adjusted by adjusting the matching angle between the bracket (11) and the support. A hopper with a large volume and capable of storing a greater amount of feed can ensure the automatic quantitative feeding for a long time without the frequent supplement of feed. The hopper cover (8) is opened to charge the hopper (9), and the hopper (10) is connected with the opening (19) on the slider (5) through a connecting hose (12) to connect the hopper (9) with the feeding barrel (3).
5

Fig. 4. Scenograph of the base mechanism of the device

The driving rod (23) is fixed on the side wall of the base (14) and is provided with a motor (22) at its central position. The motor (22) is connected with a connecting rod (21), and the connecting rod (20) is connected with the bottom of the inclined piston (17). When feeding is required, the motor starts to drive the connecting rod to rotate, and then drive the connecting rod (20) to rotate to push up the inclined piston (17), and the motor will not stop until the inclined planes of the inclined piston (17) and the discharge outlet (2) are same. Then, the feeding can be performed. Upon the completion of feeding, the motor resumes to rotate and starts to rotate reversely, and the inclined piston (17) moves to the initial position through the hinge transmission, which is regarded as a feeding cycle.

4. Conclusion
Currently, there are few feeding devices that are movable among multiple culture barrels targeting small and medium-sized aquaculture farmers, and most of them have the disadvantages of high acquisition costs, relatively fixed positions and inconvenient use. This paper presents with a movable and cost-effective aquaculture feeding device comprising a hopper, a feeding barrel, screw and a feeding mechanism. After the required charging amount is adjusted, the slider moves downwards to seal the feeding barrel, and the baffle plate prevents the feed in the hopper from continuously flowing into the feeding barrel, so as to control the charging amount. Apart from the control of the feeding amount of aquaculture subjects, multiple culture barrels can be discharged using a feeding device equipped with a movable base, so as to reduce the aquaculture cost of farmers.

Acknowledgments
This paper is funded by Shanghai College Students Innovation and Entrepreneurship Program (Project No.: S202010264046).

References
[1] Ai YC, Li GF, Wang N. Intermixture breed techniques for fish and crab in large pond in the inshore tidal land [J]. Jiangsu Agricultural Sciences. 2006(6).
[2] Ge YJ. Analysis of development and present situation of feeding machine in China. [J]. Fishery
Modernization. 2010.

[3] Cui LX, Ni Q, Zhuang BL, et al. Design and experiment for PLC-based rail-type automatic feeding system of factory aquaculture. [J] Guangdong Agricultural Sciences. 2014(22).

[4] Zhu MS. Application of automatic feeding robot for aquatic products in industrial culture. [J]. Fujian Agricultural Machinery. 2018(1).