ISSN 2706-655X Vol.3, Issue 3: 50-57, DOI: 10.25236/IJFET.2021.030309

Design of the Novel Wisdom Trap for Monochamus Alternatus

Xiangshuai Li, Shuqi Li, Chenxin Hou, Yuqian Bai, Hongmei Zhang, Jia Song, Zishi Wang*, Hongliang Xu*

Engineering Research Center of Pesticide of Heilongjiang Province, College of Advanced Agriculture and Ecological Environment, Heilongjiang University, Harbin 150080, China
E-mail: xuhongliang@hlju.edu.cn (H. Xu), 2016048@hlju.edu.cn (Z. Wang)
**Corresponding Author*

Abstract: *In order to better use traps to monitor and control the pine wilt disease (PWD) transmitted by Monochamus alternatus, it is necessary to artificial intelligence research of traps. By consulting the literature, we found that the existing Monochamus alternatus traps generally had many shortcomings such as low levels of artificial intelligence and high operating costs. On the basis of circumventing the shortcomings of existing traps and integrating the advantages of existing traps, we designed the novel Wisdom Monochamus alternatus trap based on a new perspective of artificial intelligence. It integrates three functions of remote manipulation, pesticide application prevention and control, and natural enemy release. The research and development of this trap provide a novel basis for the protection of forestry resources and the development of new traps.*

Keywords: *Monochamus alternatus trap. Artificial intelligence. Remote manipulation. Pesticide application control. Natural enemy release*

1. Introduction

Nearly 40 years have passed since the pine wood nematode (PWN) was discovered in Zhongshan Mausoleum of Nanjing in 1982 [1]. During this period, the pine wilt disease (PWD) has caused devastating damage to millions of hectares of pine forests in China [2]. Many scenic spots have been ruined, which seriously hindered the development of China's agricultural and forestry economy. Although the control measures continue to strengthen, the PWD was still the proliferation trend. Monochamus alternatus is the main transmission vector of the PWD, so effective control measures on it are the key link to prevent the PWD [3]. Trap is an important tool for quarantine trapping and booby-trapping control of Monochamus alternatus.

With the rapid development of fifth generation (5G) mobile communication systems and artificial intelligence technologies, the Monochamus alternatus trap is also evolving from simple to complex, from single function to multi-function, and the degree of artificial intelligence is improving. After market research and literature reading, we found that the existing Monochamus alternatus traps generally required manual deployment because of their low degree of artificial intelligence. Artificial placement of traps not only increases operating costs, but also leaves an odor when placed manually, which affects the trapping effect. Existing traps cannot be used in large numbers in unmanned areas because they are easy to lose, difficult to recover and maintain. If the existing traps stayed in the wild, it would cause damage to the ecological environment.

In order to solve these problems, on the basis of circumventing the shortcomings of existing traps and integrating the advantages of existing traps, we designed the novel Wisdom Monochamus alternatus trap based on a new perspective of artificial intelligence, and applied for a utility model patent, Patent No. 202120654075.7. It integrates three functions of remote manipulation, pesticide application prevention and control and natural enemy release. It is of trans-epochal significance for the protection of agricultural and forestry resources and the development of a thriving agroforestry economy.

ISSN 2706-655X Vol.3, Issue 3: 50-57, DOI: 10.25236/IJFET.2021.030309

2. The Structure Design of the Novel Wisdom Monochamus Alternatus Trap

As shown in Figure 1, Figure 2 and Figure 3, the novel Wisdom Monochamus alternatus trap includes the gripper (1) and the flying device body (2). The lower end of the gripper (1) is fixedly connected with the flight main device (2). A plurality of motors (17) are fixedly connected to the outer side of the upper end of the flight main device (1). The flight main device (2) of the flying device can support the motor (17). The propeller (19) is fixedly connected to the upper end of the output shaft of the motor (17). The motor (17) can drive the propeller (19) to rotate to achieve the purpose of flight. The plurality of propellers (19) are centrosymmetric distribution with respect to the vertical axis of the gripper (1), limiting the specific relative positions of the plurality of propellers (19) and the gripper (1).

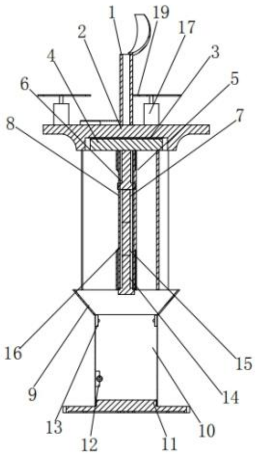

Figure 1: Sectional view of the structure of the novel Wisdom Monochamus alternatus trap with the natural enemy releaser device. (1) Gripper, (2) Flight main device, (3) Battery compartment, (4) Accumulator, (5) Fixed insect shield, (6) LED trap light, (7) Entrapment core reserve tube, (8) Through notch, (9) Funnel, (10) Insect collector, (11) Natural enemy releaser device, (12) Insect species camera recognition device, (13) Counter, (14) Entrapment core replacement catapult, (15) Entrapment core, (16) Entrapment core replacement card slot, (17) Motor, (19) Propeller.

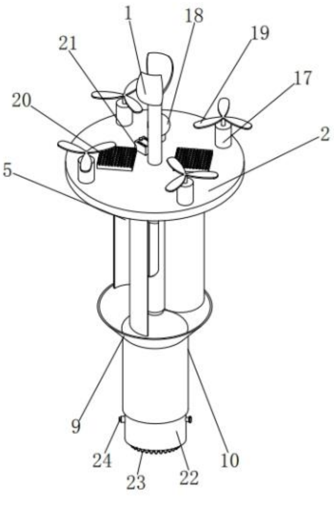

Figure 2: Schematic diagram of the structure of the novel Wisdom Monochamus alternatus trap with the pesticide liquid tank. (1) Gripper, (2) Flight main device, (5) Fixed insect shield, (9) Funnel, (10) Insect collector, (17) Motor, (18) 360 °camera identification device, (19) Propeller, (20) Solar panels, (21) Signal emitting and receiving devices, (22) Pesticide liquid tank, (23) Sprinkler head, (24) Pesticide spraying controller.

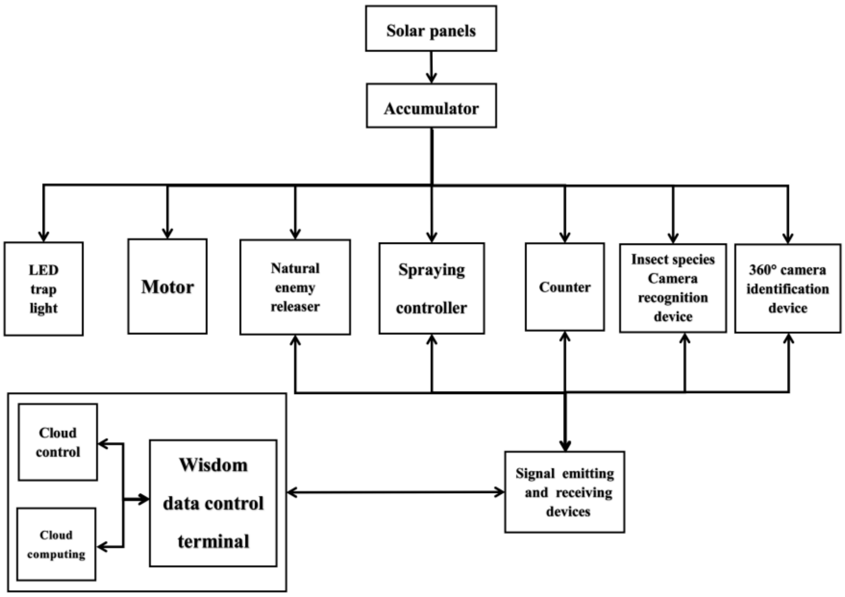

Figure 3: Schematic diagram of the novel Wisdom Monochamus alternatus trap.

The solar panels (20) are installed on both the left and right sides of the upper end of the flight main device (2). The solar panel (20) can charge the Accumulator (4). The 360 ° camera identification device (18) and the signal reflection and receiving module (21) are installed on the rear side of the upper end of the flight main device (2). The 360 ° camera identification device (18) can remotely control or automatically control the opening and closing of the gripper (1) through image recognition. All electronic components in the novel Wisdom Monochamus alternatus trap can be connected to the external intelligent data control terminal through the signal emitting and receiving devices (21).

The battery compartment (3) is processed inside the lower end of the flight main device (2), and the accumulator (4) is installed inside the battery compartment (3). The fixed insect shield (5) is fixedly connected with the lower end of the flight main device (2), and the lower end of the fixed insect shield (5) is fixedly connected with the insect collector (10) through the funnel (9). The counter (13) is installed above the inner wall of the insect collector (10), and the insect species camera recognition device (12) is installed on the left side of the inner wall of the insect collector (10). The insect species camera recognition device (12) can feed the recognized information to the counter (13). The lower end of the inner wall of the fixed insect shield (5) is fixedly connected with the entrapment core replacement (14) which can be used for pushing the entrapment core (15) to the position of the through notch (8) for easy removal. The internal center of the insect shield (5) is provided with the entrapment core replacement card slot (16). The inside of the entrapment core replacement card slot (16) is provided with the entrapment core reserve tube (7) and the entrapment core (15), and the entrapment core reserve tube (7) can place the entrapment core (15) at corresponding position. The internal wall processing of the fixed insect shield (5) has the through notch (8).

The upper end of the fixed insect shield (5) is fixed to the LED trap light (6). There is the pesticide liquid tank (22) inside the insect collector (10). The upper outer wall of the pesticide liquid tank (22) is connected with the insect collector (10) by the thread. The spraying controller (24) and the sprinkler head (23) are respectively installed at the left end and the lower part of the pesticide liquid tank (22), and the spraying controller (24) can control the switch of the sprinkler head (23). The natural enemy release (11) is provided below and outside the insect collector (10). The upper end of the natural enemy releaser device (11) is threadedly connected with the inner wall of the insect collector (10).

3. The Function of the Novel Wisdom Monochamus Alternatus Trap

3.1 Artificial Intelligence

As shown in Figure 4, the Wisdom data control terminal of the novel Wisdom Monochamus alternatus trap is based on the cognitive process of the human brain, which realizes the intelligent closed loop of "perception-analysis-decision-execution", with self-awareness and sixth sense [4]. The Wisdom data control terminal interface of the novel Wisdom Monochamus alternatus trap can receive the real-time pictures and data captured by the 360° camera identification device on the trap through the signal emitting and receiving devices. The transmitted data is used for calculation processing and autonomous analysis, so as to realize the remote control of the novel Wisdom Monochamus alternatus trap and complete various tasks.

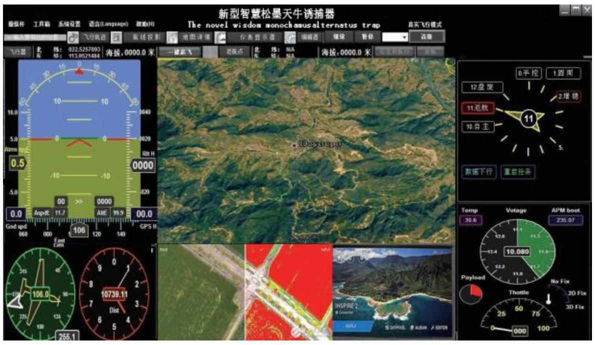

Figure 4: The Wisdom data control terminal interface of the novel Wisdom Monochamus alternatus trap.

All data and records during the using of the novel Wisdom Monochamus alternatus trap will be sent to the user's Wisdom data control terminal in real time. The 360° camera identification device is based on a new generation of artificial intelligence technology and is equipped with a multi-spectral five-channel camera. The 360° camera identification device can be transmitted to the Wisdom data control terminal through the signal emitting and receiving devices according to the degree of forest damage and some biological characteristics of Monochamus alternatus. The Wisdom data control terminal will automatically calculate the area where the Monochamus alternatus population density is the highest to place the traps, and optimize the best placement area for natural enemies and the best spraying area for preventing and controlling Monochamus alternatus.

3.2 Recognition and Counting

As shown in Figure 5, whenever an insect falls into the insect collector, the insect species camera recognition device installed on the left under the insect trap can identify the fallen insects. If it is identified as Monochamus alternatus, it will transmit a signal to the counter and the Wisdom data control terminal to automatically increase its indication by 1, otherwise the counter indication remains unchanged. The novel Wisdom Monochamus alternatus trap can not only count the number of trapped Monochamus alternatus and display it on the Wisdom data control terminal interface, but also provide early warning in Monochamus alternatus flooding or invasion of key Monochamus alternatus prevention areas.

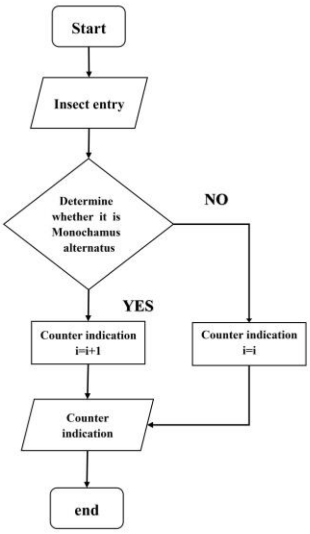

Figure 5: The flow chart of the counter identification of the novel Wisdom Monochamus alternatus trap.

ISSN 2706-655X Vol.3, Issue 3: 50-57, DOI: 10.25236/IJFET.2021.030309

3.3 Remote Manipulation

When this novel Wisdom Monochamus alternatus trap is working, the motor starts to rotate the propeller, driving the whole trap to move in flight. As shown in Figure 6, the signal emitting and receiving devices can be connected to the BeiDou Navigation Satellite System to transmit flight instructions to the trap and provide accurate GPS positioning and navigation. When the novel Wisdom Monochamus alternatus trap flies to the operating area, the Wisdom data control terminal performs image processing on the images transmitted back from the 360 °camera recognition device in real time to find the best place to put it, and then realize remote manipulation. Based on the remote manipulation function of the novel Wisdom Monochamus alternatus trap, the "the novel Wisdom-class platform for remote manipulation Monochamus alternatus trap" was developed, and the software copyright was applied for, registration number: 2021SR0699322.

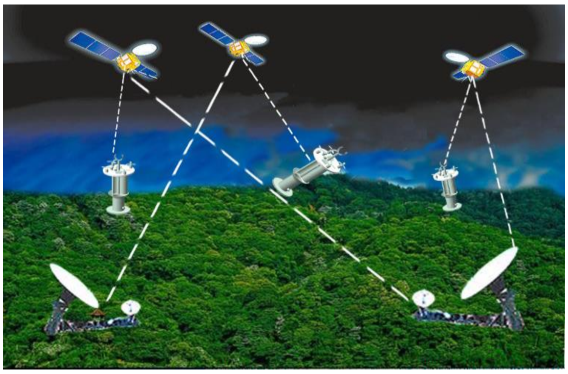

Figure 6: Schematic diagram of remote release of the novel Wisdom Monochamus alternatus trap.

3.4 Natural Enemy Release and Pesticide Application Prevention and Control

As shown in Figure 1, Figure 2 and Figure 7, the trap can be mounted with two kinds of devices: the natural enemy release and the pesticide liquid tank, which can not only trap a large number of Monochamus alternatus, but also apply medicine and release natural enemies to control Monochamus alternatus population flooding. The trap insect collector can be connected with the natural enemy releaser device to release Monochamus alternatus infected with parasitoid wasps or parasitoid flies, and infect more Monochamus alternatus, so as to achieve better prevention and control effect. Whenever a novel data Wisdom Monochamus alternatus trap in a certain area issues an early warning, the Wisdom control terminal will mobilize the trap near the early warning area to fly to the early warning area. The traps with the two types of devices are respectively turned on the pesticide spraying controller and the natural enemy release device to conduct pesticide application and release the natural enemy prevention and control. If the traps mobilized are not enough to control the pest situation, the Wisdom data control terminal will mobilize other idle traps to go. The 360 °camera recognition device of the novel Wisdom Monochamus alternatus trap is equipped with a multi-spectral five-channel camera. It can calculate the optimal spraying amount, spraying location, and spraying time of the insecticide through spectral analysis, and optimize the use of Monochamus alternatus insecticide.

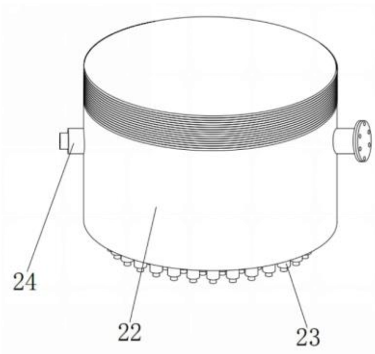

Figure 7: The novel Wisdom Monochamus alternatus trap pesticide liquid tank. (22) Pesticide liquid tank, (23) Sprinkler head, (24) Pesticide spraying controller.

3.5 Fixed Insect Shield Optimization

During the use, the entrapment core inside the entrapment core replacement card slot and the use of the LED trap light enables the Monochamus alternatus to fly towards the fixed insect shield. Monochamus alternatus belongs to the Coleoptera insects, and most of the Coleoptera insects have the habit of pseudo-death. When Monochamus alternatus encounters the fixed insect shield during the flight, it will immediately retract its wings and enter a state of suspended animation, and fall into the insect collector through the funnel to achieve trapping. The novel Wisdom Monochamus alternatus traps optimize the cross fixed insect shields used in most traps on the market. As shown in Figure 8, it is optimized into the fixed insect shield composed of 3 semi-cylindricals with the centerline at an angle of 120 °and the same direction. The semi-cylindrical structure of the fixed insect shield can increase the impact area of Monochamus alternatus within the same length and improve the trapping efficiency.

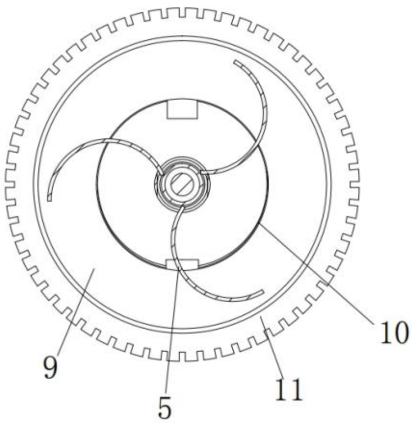

Figure 8: Top-down cross-sectional structure diagram of the novel Wisdom Monochamus alternatus trap. (5) Fixed insect shield, (9) Funnel, (10) Insect collector, (11) Natural enemy releaser device.

3.6 Long Maintenance Cycle

The novel Wisdom Monochamus alternatus trap is designed based on the three physiological characteristics of Monochamus alternatus Color tropism, phototaxis and chemotaxis. Figure 9 and Figure 10 were the simulation renderings of day and night operation of the novel Wisdom Monochamus alternatus trap made by Lumion 9 software.

Figure 9: Simulation diagram of forest operation of novel Wisdom Monochamus alternatus trap.

ISSN 2706-655X Vol.3, Issue 3: 50-57, DOI: 10.25236/IJFET.2021.030309

Figure 10: Simulation diagram of the novel Wisdom Monochamus alternatus trap at night.

3.6.1 Increase Maintenance Cycle Based on Color Tropism

Studies have shown that brown can improve the trapping effect of the black armyworm. Therefore, As shown in Figure 9, the novel Wisdom Monochamus alternatus trap is set as a tan as a whole. The color of the novel Wisdom Monochamus alternatus trap does not fade for a long time. It can trap Monochamus alternatus for a long time and increase the maintenance period.

3.6.2 Increase Maintenance Cycle Based on Phototaxis

As shown in Figure 1, because the solar panel on the top of the trap can charge the accumulator, and the accumulator is supplying power for the LED trap light, this can greatly improve the maintenance cycle of the trap. Because there is no need to manually replace the battery of the LED trap lamp for a long time, it can greatly increase the maintenance cycle.

3.6.3 Increase Maintenance Cycle Based on Chemotaxis

The size of the entrapment core replacement card slot can be adjusted, and most types of entrapment core on the market can be used [5]. When the Wisdom data control terminal detects that the entrapment core in the entrapment core reserve tube has reached its service life, it will issue a command to activate the entrapment core replacement catapult to eject the spare decoy core in the entrapment core reserve tube while ejecting the entrapment core that has reached its service life. The entrapment core reserve tube is completely airtight and dry, which can protect the entrapment core in the tube from failure. The design of the entrapment core reserve tube can greatly increase the maintenance cycle. When all the entrapment core are used up, the Wisdom data control terminal will call the novel Wisdom Monochamus alternatus trap to fly back, and continue to perform operations after maintenance and replenishment. There is no need to manually replace the trap core during the use of the novel Wisdom Monochamus alternatus trap, which can greatly increase the maintenance cycle.

Based on the above three designs, the long maintenance period of the novel Wisdom Monochamus alternatus trap was guaranteed.

4. Conclusion and Discussion

By summarizing the advantages and disadvantages of traditional traps, we found that the existing Monochamus alternatus traps had a low degree of artificial intelligence, resulting in high labor costs. In order to solve this problem, a novel Wisdom Monochamus alternatus trap was designed based on the new perspective of artificial intelligence. The artificial intelligence of the novel Wisdom Monochamus alternatus trap can reach the level of wisdom, and it has the functions of remote manipulation, natural enemy release and pesticide application prevention and control.

Table 1 Comparison and analysis table of functions between the novel Wisdom Monochamus alternatus trap and the traditional Monochamus alternatus trap

Comparing work ability	**The novel Wisdom Monochamus alternatus trap**	**Traditional Monochamus alternatus trap**
Degree of artificial intelligence	Wisdom	Up to ingenious level only
Operating cost	Low cost	High cost
Placement method	Remote manipulation placement	Manual placement
Design based on physiological characteristics	Combination of phototaxis, chemotaxis, and color tropism	Single feature only
Recycling situation	GPS positioning tracking, 100% recycling	Easy to lose, about 70% recycled

The novel Wisdom Monochamus alternatus trap integrates most of the advantages of traps on the market, while also overcome most of the shortcomings of traps [6]. As the degree of artificial intelligence increases, labor costs can be greatly reduced. Research and development of the novel Monochamus alternatus traps remotely controlled by artificial intelligence will more accurately and efficiently monitor and control the PWD transmitted by Monochamus alternatus. Besides, it will surely reduce operating costs once promoting into the market in the future. This research can promote the healthy development of country's agricultural and forestry ecological environment.

Acknowledgments

This work was supported by the Natural Science Foundation of Heilongjiang Province under Grant (grant number LH2019C055), the Project funded by China Postdoctoral Science Foundation under Grant (grant number 2019M651316), the Heilongjiang Provincial Postdoctoral Science Foundation under Grant (grant number LBH-Z18261), the Department of Education of Heilongjiang Province under Grant (grant numbers 2020-KYYWF-1031, 2020-KYYWF-1030, 2020-KYYWF-1029, 135409216), and Heilongjiang University Graduate Innovative Research Fund Project (grant number YJSCX2021-087HLJU).

References

[1] Moens, M., Li, H., Shen, P., Fu, P. and Lin, M. (2007) Characteristics of the emergence of monochamus alternatus, the vector of bursaphelenchus xylophilus (nematoda: aphelenchoididae), from pinus thunbergii logs in nanjing, china, and of the transmission of the nematodes through feeding wounds. Nematology, 9(6), 807-816.
[2] Li, H., Zhou, G.Y., Liu, J.A. and Zhang, H.Y. (2011) Study on pine wilt disease and its control situation. Applied Mechanics and Materials, 55-57, 567-572.
[3] Sugimoto, H., Fukuta, M. and Togashi, K. (2020) Yearly changes in dispersal and life-history traits of Monochamus alternatus Hope with reference to its outbreak. Journal of Applied Entomology, 144(6), 459-467.
[4] Zhong, R.Y., Xun, X., Klotz, E. and Newman, S.T. (2017) Intelligent manufacturing in the context of industry 4.0: a review. Engineering, (3), 616-630.
[5] Zhao, J.N., Jiang, P., Wu, C.S., Sun, S.L. and Lin, C.C. (2000) Studies on monochamus alternatus attractants and the attractability. Forest Research, 13(3), 249-256.
[6] Nakamura, K., Sone K. and Ookuma, H. (1999) Modification of a commercial attraction trap for live trapping of monochamus alternatus(hope) adults(coleoptera;cerambycidae). Japanese Journal of Applied Entomology and Zoology, 43(1), 55-59.