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CASE REPORT

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Successful rehabilitation and release of two severely injured Formosan black bears (*Ursus thibetanus formosanus*) with desensitization to routine treatment procedures

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Abstract

Background Wildlife rehabilitation is crucial for the recovery of injured endangered species; however, this process can induce significant stress, potentially leading to secondary injuries and complications. This case report details the rehabilitation of two severely injured Formosan black bears (*Ursus thibetanus formosanus*) with desensitization techniques as an alternative approach to reducing stress while promoting voluntary cooperation during treatment.

Case presentation Patient 1 was an adult female bear with injuries, including the loss of the second, third and fourth phalanges of the left forelimb and extensive necrosis of the right palm. Patient 2 was a subadult male suffering from multiple gunshot wounds, severe necrosis of the distal part of the right wrist, and a fracture of the right mandibular ramus and left humerus. Both bears underwent desensitization training, which fostered calmness during routine procedures and facilitated smooth recovery throughout rehabilitation. Pre-release training focused on rebuilding physical capacity and developing natural behaviors, as well as human avoidance, to increase survival and reduce human-bear conflicts.

Conclusions The successful outcomes, characterized by complete recovery and avoidance of human interactions, underscore the effectiveness of desensitization strategies in wildlife rehabilitation. This approach not only enhances the quality of medical care but also mitigates the risks of post-release conflicts, contributing to the conservation of endangered species.

Keywords Desensitization techniques, Formosan black bears, Wildlife rehabilitation

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Background

Wildlife rehabilitation focuses primarily on the treatment and temporary care of injured, diseased, and displaced indigenous animals, with the ultimate goal of releasing them into their appropriate natural habitats [1]. However, during the rehabilitation process, wildlife undergoing rehabilitation often experience significant stress due to exposure to unfamiliar surroundings and distressing treatment procedures [2, 3]. Additionally, recently rehabilitated animals often exhibit fear and a "fight or flight" response when approached by humans [4, 5], which can lead to secondary injuries. Both stress and secondary injuries can impede recovery from injury or illness, prolong rehabilitation, and increase the risk of mortality [5, 6].

Consequently, traditional wildlife rehabilitation primarily reduces stress by providing hiding areas and minimizing physical, visual, olfactory, and auditory contact between animals and caretakers [1, 3]. Implementing these practices can also prevent wildlife from becoming habituated to human interaction, reducing potential post-release conflicts [1, 3].

Although hiding areas are commonly used to reduce stress, they can make it difficult to assess an animal's recovery progress, detect early signs of complications, or administer necessary medical treatments. This limitation highlights the need for alternative approaches that balance stress reduction with effective medical intervention.

In situations where interaction is unavoidable, such as when animals require intensive care, additional measures or sedation may be necessary, despite the risk of secondary injuries. Given these challenges, alternative strategies such as desensitization techniques might be considered to overcome the dilemmas commonly encountered during the rehabilitation period.

Positive reinforcement techniques are widely used to manage stress in captive wildlife [9–10]. These techniques enhance husbandry and medical care by encouraging voluntary cooperation from animals [7–9]. While full voluntary cooperation may be unfeasible for wild animals in rehabilitation due to time constraints, desensitization can be used to condition them to tolerate distressing stimuli by providing positive rewards [9]. Although desensitization has been extensively applied to reduce anxiety in captive wildlife [10, 11], its application in wildlife rehabilitation is rare. However, its benefits are crucial for reducing stress during rehabilitation [12]. Desensitization techniques can offer an alternative by gradually exposing animals to necessary medical procedures in a controlled manner while reinforcing positive behaviors. Concerns exist about conditioning animals to human interaction during rehabilitation, which may lead to post-release conflicts. However, this habituation can be prevented by assigning one or two specific caretakers and employing pre-release training, which is a common practice in soft release procedures [13–15].

This case report describes the rehabilitation procedures, incorporating desensitization techniques, for two severely injured Formosan black bears (*Ursus thibetanus formosanus*). Through desensitization, both bears recovered without secondary injury and maintained a stable status throughout treatment.

Desensitization was chosen because both bears had severe injuries requiring intensive medical care, and traditional methods such as isolation and repeated sedation would have increased the risk of prolonged stress, secondary injuries, or incomplete treatments. By implementing desensitization, the bears were able to cooperate during treatment without excessive sedation, ensuring a stable recovery while preserving their ability to return to the wild.

Case presentation

Patient 1

On April 20, 2020 (Day 0), a female Formosan black bear (*Ursus thibetanus formosanus*), weighing approximately 52.5 kg, was found ensnared in a steel snare with its left forelimb caught in the Jinping trail in Taitung County, Taiwan. The bears were anesthetized and transported to the Pingtung Rescue Center for Endangered Wild Animals (PTRC). Three days after arrival, the bear was anesthetized via a combination of 2 mg/kg Zoletil® (Virbac, France) and 0.02 mg/kg Dexmedetomidine (Dexdomitor®, Zoetis, USA) for examinations. A computed tomography scan revealed the loss of the second, third and fourth distal phalanges of the left forelimb, with extensive swelling and necrosis in the palmar aspect of the right forelimb due to entanglement with the snare wire (Fig. 1a and c). Surgery was performed to amputate the second, third and fourth digits of the left forelimb and debride the necrotic area (Fig. 1d). Despite being housed in an enclosure with an ambient temperature of 22–25 °C and humidity of 60–70%, the bear exhibited hiding behavior, refused to eat, and avoided medication. This behavior hindered wound management, leading to further necrosis and infection of surgical sites. On April 28, 2020 (Day 8), additional surgery and debridement were performed due to secondary infection of the wounds, and the bear was transferred to an intensive care cage. A senior caretaker was assigned to postoperative care, and desensitization training was initiated. The training focused on familiarizing the bear with routine procedures, including cage cleaning, feeding, and wound care. The caretaker quietly and gently conducted these tasks, offering food mixed with antibiotics and debriding the wound with 1% betadine via a catheter for approximately 30 min twice a day. 5 ml of honey water was used as a reward when the bear remained calm during the procedures. Postoperative

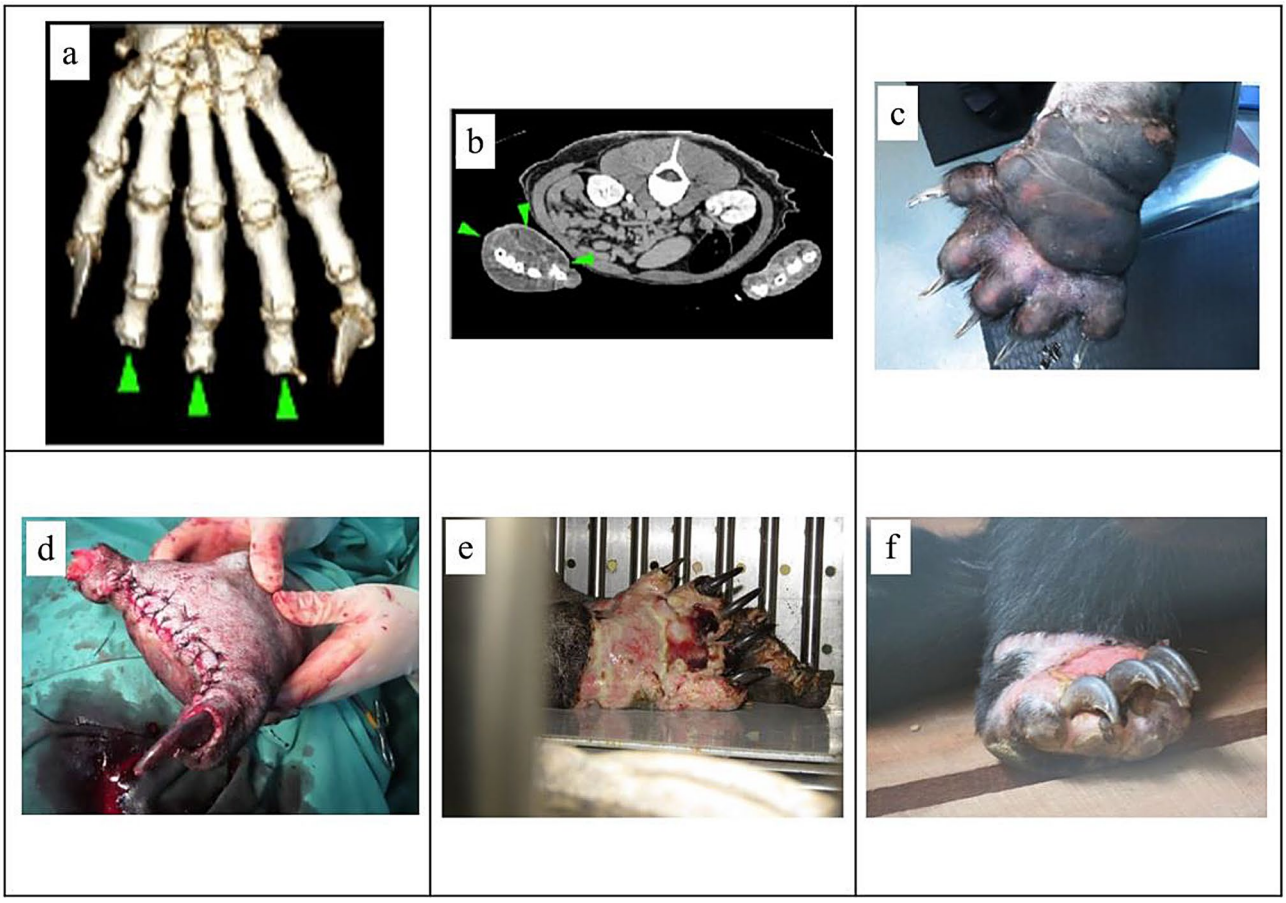

Fig. 1 Physical examination, computed tomography scan and surgical treatment of Patient 1 Formosan black bear. (**a**) A computed tomography scan revealed the loss of the second, third and fourth distal phalanges (arrowhead) of the left forelimb; (**b**) and (**c**) extensive swelling and necrosis in the palm of the right forelimb (arrowhead); (**d**) amputation of the second, third and fourth digits of the left forelimb; (**e**) and (**f**) two days and 7 weeks after surgery and debridement of the right forelimb, respectively

care included administering medications twice daily by embedding them in steamed sweet potatoes or bananas, or other palatable food items. The specific food used varied daily, based on the animal's appetite and individual preferences, to ensure consistent intake and minimize stress The prescribed medications were 2 mg/kg Tramadol (Tramtor®, Taiwan patron chemical & pharmaceutical co., Taiwan), 1 mg/kg Cetirizine (Cetia®, Taiwan, biotech co., Taiwan), 5 mg/kg Enrofloxacin (Baytril®, Bayer Animal Health, USA), and 5 mg/kg Lysozyme (Suzyme tablets, Yusheng Pharmaceutical Co., Taiwan). Wound cleaning was performed once daily, coinciding with the evening feeding. The caretaker recorded the daily food intake and the quantity of each type of food and monitored the animal's feeding behavior as it transitioned from liquid to soft-solid foods. Wound photos and behavioral observations were taken daily during enclosure cleaning. Additionally, three cameras were installed at elevated positions around the enclosure to enable real-time monitoring of the animal. Desensitization was achieved by the third day of training. (online video: https://youtu.be/PXaJHE4mldA). This behavior showed a reduction in stress in the animal and increased cooperation with the caretaker. The right forelimb wounds gradually recovered and fully healed after 53 days of rehabilitation (Fig. 1e and f). The individual was then transferred to a larger enclosure and released back into its natural habitat after 105 days of rehabilitation (on August 6, 2020). During the pre-release period, several measures were taken to prevent human habituation, including providing natural foods typical of wild Formosan black bears, minimizing contact between caretakers and assessing bears' behavior to ensure that they maintained avoidance by humans (Table 1). If the bear demonstrates good physical health, foraging and hunting abilities, behavioral adaptability, and an avoidance response toward humans, including caretakers, veterinarians, and unfamiliar individuals, it will be considered a suitable candidate for release into the wild. Both behavioral assessments and conditioning sessions were conducted once per week to minimize human-animal interaction and reduce the risk of habituation.

Table 1 Summary of the rehabilitation of the two severely injured Formosan black bear (Ursus thibetanus formosanus) in Taiwan

Patient 1							
Sex	Age	Weight (kg)	Physical assessment	Surgery	Recovery and Rehabilitation	Pre-release training	Release
Female	Adult	Day of arrival: 52.5 Day of release: 60.2	2020/04/20 Loss of the second to fourth distal phalanges of the left forelimb with an extensive necrosis on the right palm	1. 2nd, 3rd and 4th finger of left palm amputation (2020/04/23) 2. Necrotic tissue of right palm scraping and debridement (2020/04/28)	1. Intensive care cage[1] (53 days) 2. Indoor room[2] (52 days)	Rebuild the physical capacity and avoid habituation to human	Central Mountain Range, Taitung (108 days after rescue) (2020/08/06)
Patient 2							
Sex	Age	Weight (kg)	Physical assessment	Surgery	Recovery and Rehabilitation	Pre-release training	Release
Male	Subadult	Day of arrival: 46.5 Day of release: 47.4	2020/12/11 Steel cable trap entangled around its right forelimb and multiple gunshot wound	1. Amputate the right forelimb radius and ulna 2. External skeletal fixation of right mandible 3. Remove bullet around left humerus (2020/12/14)	Intensive care cage (75 days)	Preparation for returning to wild and behavior assessment in outdoor enclosure[3] (99 days)	Central Mountain Range, Taitung (248 days after rescue) (2021/08/15)

[1]Small cage size: 1.2 × 1.0 × 1.1 m; [2]Indoor room enclosure: 9 × 10 × 2.5 m; [3]Outdoor enclosure: ≥750 m^2

Patient 2

On December 11, 2020 (Day 0), a subadult male Formosan black bear was found in the mountainous area near Kanding village, Taitung County, Taiwan, with a steel cable trap entangled around its right forelimb and multiple gunshots. The bear was transported to the PTRC for wound treatment and intensive care. The patient was anesthetized via blow darts containing a combination 2 mg/kg of Zoletil® (Virbac, France) and 0.02 mg/kg Dexmedetomidine (Dexdomitor®, Zoetis, USA) for physical examination and CT scanning three days after arrival. The CT scan revealed severe necrosis of the distal part of the right wrist caused by snare entanglement. Multiple gunshot wounds were observed, including two penetrating wounds on the right forearm, a comminuted fracture of the left humerus with a bullet fragment lodged in the subcutaneous tissue, and a comminuted fracture of the right mandibular ramus with circular gunshot wounds on the cheek and jaw (Fig. 2a and d). Surgery was performed to amputate the right radius and ulna, and external skeletal fixation was applied to the right mandible (Fig. 2e and f). The bullet around the left humerus was removed; however, owing to the closed nature of the humerus fracture and the young age of the bear, no fixation of the humerus was conducted. After surgery, the bear was placed in an intensive care cage (2.4 × 1.0 × 1.1 m) in the isolation room.

Desensitization training, similar to that used in Patient 1, was initiated on the second day of post-surgery. Given the bear's severe injuries and the experience from Patient 1, desensitization was deemed crucial, particularly as the bear required hand-feeding liquefied food due to mandibular injury. The desensitization plan was as follows: There were two training sessions per day, one in the morning and one in the evening, each lasting 20–30 min. Initially, a specific caretaker quietly entered the enclosure and stayed near the bear without direct interaction. The caretaker offered liquefied food from a distance, gradually decreasing the distance over time. Positive reinforcement award, such as honey-water, was provided when the bear remained calm during feeding and wound debridement.

Despite these efforts, the bear did not eat for nearly the first week. For pain relief, 7.5 μg/kg buprenorphine (Buprenorphine Injection, Shinlin Sinseng Pharmaceutical Co., Taiwan) was administered intramuscularly on the first, third- and fifth-days post-surgery. Once the bear began eating, honey and medications (the same as Patient 1) were mixed with liquefied food and hand-fed for one week to ensure proper intake of the food and medicine. On January 16, 2021 (Day 36), the bear removed the external fixator of the right mandible on its own without affecting its feeding behavior. On January 22, 2021 (Day 42), an X-ray examination was performed under anesthesia, revealing good bone healing of the left humerus and right mandibular ramus, with an increase in body weight to 55.4 kg compared with its arrival weight. We concluded that the bear had recovered from injuries, and pre-release training was conducted in a large outdoor enclosure (approximately 750 m^2). The pre-release enclosure was designed to simulate a natural environment while allowing controlled monitoring. It featured diverse vegetation, climbing structures, logs, and natural substrates to encourage natural foraging and movement behaviors. A water source was available for drinking and bathing, and hidden food was placed to promote food-seeking instincts. During this period, we focused on three key aspects: (1) natural food recognition, with natural food collected by forest rangers on the base of the diet of the wild population; (2) rebuilding physical capacity

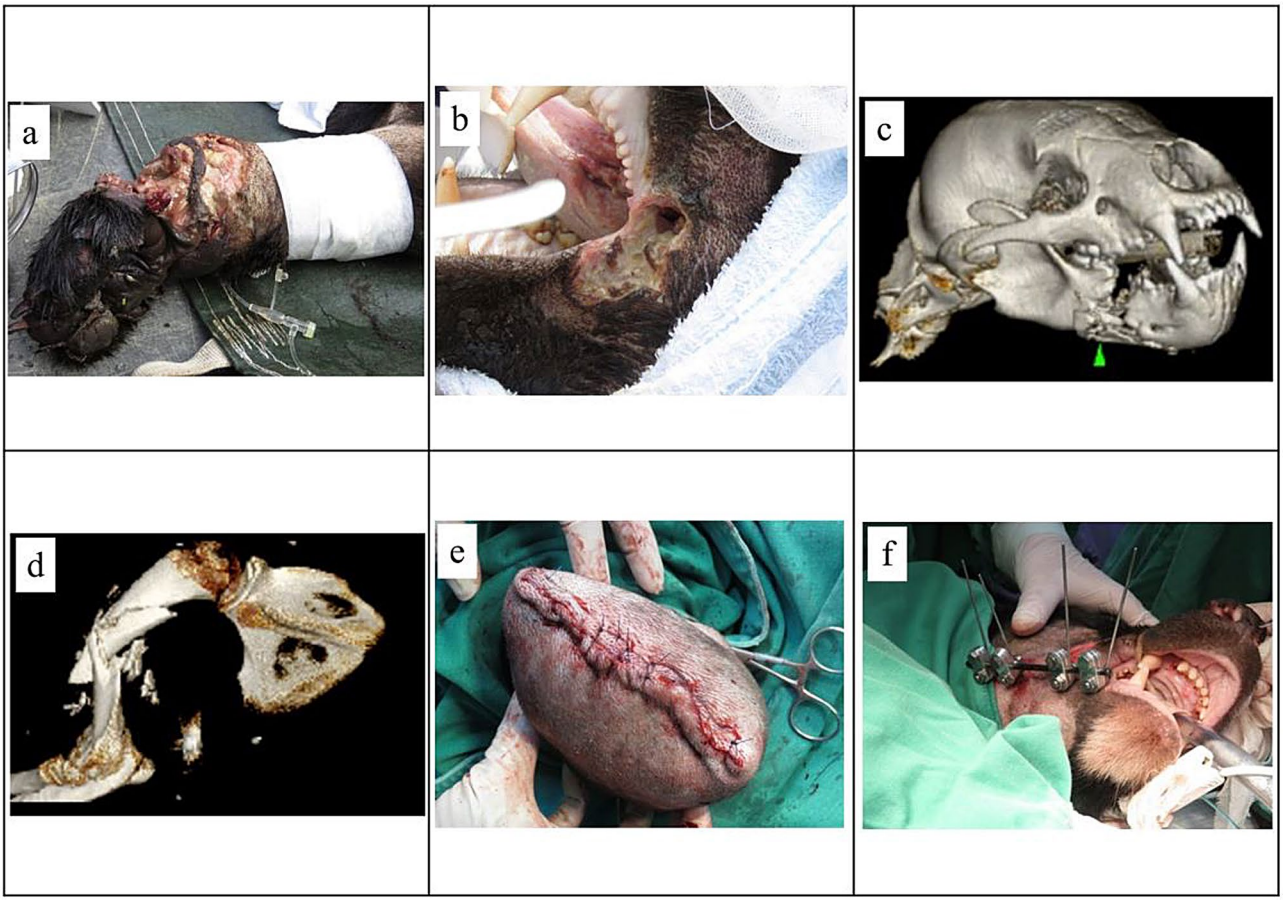

Fig. 2 Physical examination, computed tomography scan and surgical treatment of Patient 2's Formosan black bear. (**a**) Necrosis of the distal part of the right wrist; (**b**) circular gunshot wounds on the cheek and jaw; (**c**) fracture of the right mandibular ramus; (**d**) comminuted fracture of the left humerus; (**e**) amputation of the right radius and ulna; (**f**) external skeletal fixation of the right mandible

to perform natural behaviors, including running and tree climbing, adapting to ambulation on three limbs (online video: https://youtu.be/ByA8wVCktyA); and (3) human threat avoidance training, in which loud noises were used as aversive techniques to condition bears to avoid humans. The bear was released on August 15, 2021 (Day 249) and was fitted with a GPS collar and ear tag for post-release tracking and identification. The bear was monitored using a GPS collar for over a year, during which it established a home range within its natural habitat and exhibited avoidance behavior toward human presence, as determined by its GPS tracking data [16]. After one year, the GPS collar was remotely dropped and retrieved by a forest ranger.

Discussion

In this study, we present the successful rehabilitation of two Formosan black bears with severe injuries. We emphasize the importance of desensitization training in the rehabilitation process. However, we did not describe the treatment routines and medications in detail, as they follow common procedures of wound management. During the rehabilitation period, Patient 1 was first replaced in an enclosure with a hiding area following amputation. However, the individual hid and refused to eat due to severe distress and pain. This situation significantly increased the difficulty of monitoring the wound and administering medical treatment. As expected, the amputation site on the left forelimb exhibited inflammation, whereas necrosis on the right limb continued to progress. After secondary surgery and relocation to an intensive care cage for desensitization training and medical treatment, Patient 1 underwent procedures, including food provision, cage maintenance, and wound lavage, and began eating within 48 h. The bear's adaptation to rehabilitation procedures greatly facilitated recovery. In comparison, although Patient 2 required six days of desensitization training, the outcome was similar to that of Patient 1, as the recovery proceeded smoothly. Patient 2, a subadult with more severe injuries, likely faced greater challenges in adaptation due to the stress of an unfamiliar environment and painful conditions [12]. The time required for successful positive reinforcement training can vary depending on factors such as target

behavior, environment, species, and individual history [11, 17, 18]. Nevertheless, we expected desensitization training to be accomplished relatively quickly because the primary goal, compliance with medical care and rehabilitation, was simpler than complex behavior training [8].

To increase the chances of rehabilitation to release success, minimizing the duration of rehabilitation is recommended [19]. At the same time, inherently stressful conditions in wildlife rehabilitation sanctuaries can exacerbate illness or, worse, lead to secondary injury [3, 6]. This could prolong the rehabilitation period and increase mortality [20]. In Patient 1, although the caretaker initially placed the bear in an enclosure with a hiding area to reduce stress, the bear continued to refuse food, and the wound worsened. Thus, desensitization training was implemented with the goal of reducing distress and encouraging voluntary cooperation during treatment [7–9].

During the rehabilitation period, bears may develop habituation to humans or anthropogenic environments, which can reduce their survival after release [14, 21, 22]. Therefore, pre-release training is recommended to restore threat avoidance behavior and natural food recognition [14, 15]. To mitigate the risk of habituation to humans, we limited human interaction to one or two caretakers and conducted pre-release tests to ensure that avoidance behaviors were maintained. In the final stages of rehabilitation, bears were provided only with natural food sources to reinforce wild foraging behavior. Additionally, behavioral assessments were conducted before release to confirm that both bears exhibited avoidance responses to unfamiliar humans, ensuring that desensitization did not compromise their survival instincts.

In our cases, Patient 1 involved an adult bear that exhibited human avoidance behavior during the pre-release period. Pre-release training focuses on adapting to forelimb amputation and rebuilding physical capacity, such as tree climbing and hunting [23]. However, we were unable to evaluate bear survival after release because of the premature detachment of the GPS collar two days after release. Although auto-trigger cameras were installed around the release site, no images were captured after the bear's release. making its long-term survival uncertain. Despite this, the bear successfully recovered from its severe injuries. In contrast, in Patient 2, a subadult bear underwent a longer pre-release training period (approximately six months) than did in Patient 1 (1.5 months). The extended training was due to the consideration of bears' inexperience in the wild, as well as the timing of the release, which coincided with early autumn, a more stable climate, and an abundance of food resources (acorn season) [24]. On the basis of one year of GPS tracking data and no further invasion into the residence area, we consider the rehabilitation of Patient 2 to have been successful [14]. This suggests that despite undergoing desensitization training, the bear maintained natural avoidance behaviors in the wild. Moreover, the successful rehabilitation of Patient 2 demonstrated that human habituation can be prevented from wildlife casualties under desensitization training for disease treatment [21, 22, 25].

Conclusion

In conclusion, this report describes the rehabilitation of two severely injured Formosan black bears and highlights the significance of desensitization training in improving the success of rehabilitation outcomes. Desensitization effectively reduces distress and promotes voluntary cooperation with rehabilitation procedures, contributing to the overall success of the process. Additionally, we demonstrated that human habituation can be minimized through pre-release training, thereby reducing potential human-bear conflicts after release. While these findings support the advantages of desensitization, its efficacy may vary depending on species-specific behaviors, individual temperament, and the rehabilitation environment. Further research is needed to evaluate the effectiveness of desensitization techniques in other wildlife species, particularly those with distinct cognitive or social structures. Additionally, challenges such as the time-intensive nature of training, the necessity of skilled personnel, and potential ethical considerations should be addressed when implementing desensitization in broader rehabilitation programs. Refining and adapting desensitization techniques is expected to enhance rehabilitation quality and support the recovery of endangered species. However, future studies should investigate its limitations and explore species-specific modifications to optimize its effectiveness.

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Author contributions

AC: Writing– original draft, Writing– review & editing. YT: Responsible for the patients' treatment. LL: Performed the imaging examinations. CC: Conceptualization, Investigation, Writing– original draft, Writing– review & editing, Supervision.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Ethical review not required– retrospective report of clinical cases.

Consent for publication
This study was a case report of two wild Formosan black bears and is not applicable to this section.

Competing interests
The authors declare no competing interests.

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