

Welfare Assessment of Flight-restrained Captive Birds: Effects of Inhibition of Locomotion

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Abstract

Morphological and physiological adaptations have allowed birds to utilize flying as part of the primary locomotion. However, birds in captivity are often deprived of this natural skill due to limited living space or wing amputation. This article aims to investigate the essentialness of flight and welfare assessment of flight restraint in captive birds, using animal-based measurement. Ten wild-caught great mynahs (*Acridotheres grandis*) were chosen as test subject and evaluated in three separate studies. In pathology study, bird wings were partially amputated to assess possible neuroma formation at the site of amputation. The birds involved in this study were evaluated on day 20 and day 40 post surgery. We found that wing amputation did not result in neuroma formation. In ethology study, spatial preference of the captive birds was evaluated by providing cages with different structures. We noticed that the birds indicated higher preference for spaces that were bigger or with higher vertical space with or without food provided. In physiology study, strength of pectoralis muscle was evaluated with electromyography in both wild birds and birds that were flight restrained for 40 days. The results indicated that strength of pectoralis muscle diminished significantly in birds with flight restraint. This research suggested that captive birds were still highly inclined to use flight as means of locomotion, and provided useful information as to how enclosures of captive birds should be carefully designed for better animal welfare.

Keywords: animal welfare, captive birds, electromyography, flight restraint, great mynah, wing amputation

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บทคัดย่อ

การศึกษาสวัสดิภาพสัตว์ในนกที่ถูกกักขัง: ผลที่เกิดจากการจำกัดการบิน

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ลักษณะทางกายภาพและการปรับตัวทางสรีรวิทยา ทำให้นกสามารถใช้การบินเป็นส่วนหนึ่งของการเคลื่อนไหวหลัก แต่อย่างไรก็ตามนกในกรงมักจะขาดโอกาสนี้เนื่องจากพื้นที่จำกัด หรือถูกตัดปีก การศึกษานี้มีวัตถุประสงค์ เพื่อศึกษาความสำคัญของการบินและเพื่อประเมินสวัสดิภาพสัตว์ในนกที่ถูกขัง โดยใช้การวัดจากสัตว์ ทำการคัดเลือกนกเอี้ยงหงอนป่า (*Acridotheres grandis*) จำนวน 10 ตัว และทำการประเมินแยกกันในการทดสอบ ในการศึกษาด้านพยาธิวิทยา ทำการตัดปีกนกบางส่วนเพื่อประเมินโอกาสการเกิดเนื้องอกของเส้นประสาทที่จุดที่ทำการตัดปีก และทำการประเมินผลในวันที่ 20 และ 40 วันหลังการผ่าตัด พบว่าการตัดปีกไม่ได้ส่งผลให้เกิดการเกิดเนื้องอกของเส้นประสาท ในการศึกษาพฤติกรรมตามธรรมชาติ ศึกษาความชอบของพื้นที่การกระจายของนกที่ถูกขังโดยสร้างกรงที่มีโครงสร้างที่ต่างกัน สังเกตเห็นว่านกชอบบินในบริเวณที่ใหญ่กว่า หรือมีพื้นที่ในแนวตั้ง โดยอาจจะไม่มีหรือไม่มีอาหารก็ได้ ในการศึกษาทางสรีรวิทยาถึงความแข็งแรงของกล้ามเนื้อจากการวัดคลื่นไฟฟ้ากล้ามเนื้อในนกป่าและนกที่ถูกจำกัดการบินเป็นเวลา 40 วัน ผลการทดลองพบว่าความแข็งแรงของกล้ามเนื้อลดลงอย่างมีนัยสำคัญในนกที่ถูกจำกัดการบิน การวิจัยครั้งนี้ชี้ให้เห็นว่านกที่ถูกกักขังยังคงมีแนวโน้มสูงที่จะใช้การบินเป็นการเคลื่อนไหวหลัก และให้ข้อมูลที่เป็นประโยชน์ต่อการออกแบบกรงสำหรับนกที่ถูกกักขังที่ควรออกแบบอย่างระมัดระวังเพื่อสวัสดิภาพสัตว์ที่ดีขึ้น

คำสำคัญ: สวัสดิภาพสัตว์ นกที่ถูกกักขัง การวัดคลื่นไฟฟ้ากล้ามเนื้อ การบังคับไม่ให้บิน นกเอี้ยงหงอน การตัดปีก

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Introduction

Locomotion is a fundamental part of life for nonsessile animals. It is responsible for a range of actions such as finding food, encountering a mate, and escaping from predators. Vertebrates can move in various ways, including swimming, crawling, walking and flying. Morphological and physiological adaptations in birds have allowed them to fly, which makes them unique in comparison with most other vertebrates. The ability and the need for flight will require the bird to reach almost its maximum pulmonary efficiency in order to take off and sustain flight. However, majority of captive birds such as flamingos, geese, ducks or swans are unable to fly. Birds' ability to fly may be restricted because they may be wing clipped or pinioned in order to be kept on display at a zoo exhibition (WAZA, 2007) or they are kept in small cages as pet birds (Engebretson, 2006). In China, Taiwan and other Asian countries, it is very common to keep song birds or ornamental birds in a small 30 cm cube around cage, allowing pet shop to fit in more cages of birds, and the pet bird household can easily display, carry and relocate the cage. However, this small, with only one perch cage

would never allow birds to fly, the only thing a bird can do within the cage would be jumping between bottom layer and the perch.

Research on effects of inhibition of animals' natural locomotion has been well-documented on: Farm animals' stereotypes; higher level of plasma cortisol, clinical signs, other abnormal behaviours and immune indicators (Mason et al., 2001; Broom, 2007); abnormal behaviors in captive wildlife (e.g. regurgitation of most great apes (Struck et al., 2007), stereotypes of wild-ranging carnivores (Clubb et al., 2004), infant mortality, low reproduction rate and glucocorticoid responses (Barry et al., 2005).

Proponents (Bautista et al., 2001) of wing amputation claimed that birds in captivity did not need to fly since they had no enemies to escape from and did not have the need to migrate or obtain food. Also, walking is at low-cost, low-yield, whereas flying is the opposite (Bautista et al., 2003). However, the denial of flight can cause physical (Graham, 1998), reproductive (Farrell, 2000) and behavioural abnormalities in birds, (van Hoek et al., 1998; Garner et al., 2003; Meehan et al., 2003) such as feather-plucking in parrots (Forbes et al., 1999; Hesterman et al., 2001).

Since there is no single indicator to determine the welfare of an animal, many studies have found that a combination of measures can be used as a tool to assess captive animals' welfare (Shepherdson et al., 2004, Hill et al., 2009). There are non-invasive physiological measures that can measure stress responses, individual behavior and temperament have great potential to assess and monitor animals. In birds, assessment typically involves measuring heart rate, glucocorticoid concentrations, adrenal gland weight and responses to ACTH challenge (Verkerk et al., 1998). The short term physical stress includes handling and transportation stress, as well as psychological stress such as social disturbance or fear. These stimuli can be assessed readily by measuring the increase in corticosterone levels in blood or by other body fluids (Shepherdson et al., 2004). For long term stress or prolonged chronic pain in birds, behavioral change can provide useful information and studies performed after debeaking of farm hens indicated that hens might suffer from chronic pain because of neuroma formation (Cheng et al., 2004).

The non-invasive methods can provide a bird access to more than one environment, with a variety of resources such as the availability of food, water or space and the opportunity to express its natural behavior. There is an assumption that they will choose in accordance with their best interest (Mason et al., 2001). Such methods are closely related to operant conditioning techniques, where birds have to work to obtain or avoid according to their environment (Dawkins, 2004).

In this study, we aimed to assess captive birds' welfare and to understand and investigate whether or not flight is essential for birds. We tried to approach these questions through animal-based measurements rather than non-animal centered-measurements.

Animal-based measurements are:

- 1) Pathology study: We attempted to examine neuroma formation in animals with previously partial amputated wings. The most common type is the formation of traumatic neuroma following nerve injury (often as a result of surgery). Neuromas occur at the end of injured nerve fibers as a form of ineffective, unregulated nerve regeneration; they occur most commonly near a scar, either superficially (skin, subcutaneous fat) or deep (e.g. after a cholecystectomy).
- 2) Ethology study: We used preference tests to find out pet birds' strategy for choosing different sizes of space and vertical and horizontal usage.
- 3) Physiology study: The pectoralis muscle is proportionately large in birds up to 35% of body weight and powers the down stroke of flight (Andrew, 2011). However, pectoralis muscle could degenerate if flight is inhibited or in a restraint

environment. In previous study, the muscle strength focused on muscle mass and required the animal to be euthanised. In human, electromyography (EMG) is applied to study muscle functions to examine the muscle's electric signals. In this research, we analyzed EMG performance instead of measuring muscle mass through stimulation response of the pectoralis muscle and potentially reduced animal euthanasia.

Materials and Methods

Selecting a bird species: We found great mynahs (*Acridotheres grandis*) to be the best subject for this study as they are the most common wild bird species found in both urban and rural areas in Taiwan. Great mynah has the intelligence to be trained for behavioral study. To reduce the number of animals used in the study, ten wild-caught birds from pet bird shop were used in this study while only five of them were successfully managed in the experiment; the birds were then released after the trial. Two pinioned birds were sent back to the pet shop.

Data collection: Data were collected between January and February, 2009.

Pathology study: Two bird wings were pinioned by certificated veterinarian under general anesthesia using isoflurane. Each individual surgical site was plucked and aseptically prepared, and hemostatic forceps were placed at the level of the carpus before the amputation of outer wing. Hemostasis was achieved with cauterization and appropriate post-operative antibiotics and analgesics were given. Surgical wounds were regularly monitored for signs of post-operative infection and bleeding. The scar tissue of cut stumps from wing surface was examined after pinioning at days 20 and 40. Neuroma formation was expected both outside the tissue and on the biopsy sample.

Ethology study: Two wild-caught birds were caged in a restricted area with one way door made of two Polyvinyl chloride (PVC) pipes. These pipes were designed with an exclusion device, and the animals were not able to re-enter through the same pipe because of the special design of the one way door. The animals were required to enter through the pipe in order to gain access to food in the restricted area. Each time the birds passed through the PVC pipe, they were recorded by video camera as one event. By calculating these events, we were able to measure their time budgets at different locations. Data were recorded for 24 hours a day, 30 days a month for standard comparison.

In this investigation we asked: 1) If birds have preference among same-size spaces with different heights. 2) Does food motivate birds to enter the restricted area? 3) Does space influence and impact birds' appetite?

We designed this model based on fur-farmed mink preference study by Mason's 2001 research.

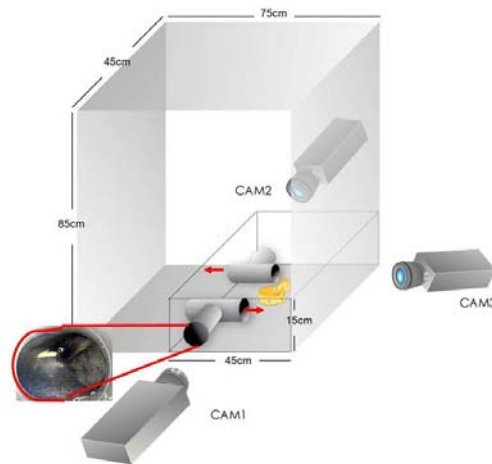


Diagram 1

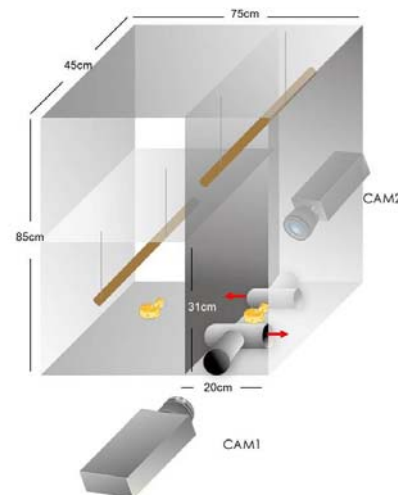


Diagram 2

In preference test 1 (Diagram 1), the cage is divided into two sections, the left being larger in size and the right being smaller in size with food and water available. In preference test 2 (Diagram 2), the cage is divided into three sections, with two areas (left lower and right) being the same size and the right being higher in height but shorter in width. Both left and right sections have food, water and a perch available.

Physiology study: In this study, EMG performance was applied to analyze pectoralis muscle strength from: 1st day caught wild bird and the same bird in a space less than wing span for 40 days. The amplitude and frequency spectrum of the EMG signal is affected by the location of the electrode with respect to the innervation zone (top electrode), the myotendonous junction (bottom electrode) and the lateral edge of the muscle (middle right electrode). The location is in the pectoralis muscle midline between the nearest innervation zone and the myotendonous junction, where the probe was attached. In this location the EMG signal with the greatest amplitude is detected. The bird was measured without sedation but physically restrained. The EMG amplifier for recording was model V75-01 (Colbourn Instruments, Lehigh Valley, Penn) and the EMG signals were analyzed by AxoScope (Axon Instruments, Union City, CA).

provided in the smaller area. These birds tended to stay mostly in the large area and only entered the small area for quick feeding. Each dot represents a

Results

Pathology study: The traumatic neuroma, which follows nerve injury (often as a result of surgery), usually occurs at the end of injured nerve fibers as a form of ineffective, unregulated nerve regeneration. It occurs most commonly near a scar, either superficially (skin, subcutaneous fat) or deep (e.g. after a cholecystectomy). In the pinion wing dissection study, the tissue from the same bird did not show any formation of neuromas at days 20 and 40 after partial wing amputation. The biopsy samples observed under a microscope 400x (Fig 1, 2) did not show any pathological changes on days 20 and 40 post surgery.

Ethology study: In the preference test 1 (Fig 3), the results revealed that the birds showed preferences for space and size. The birds preferred to stay longer in the bigger space (without food, y+) compared with the smaller space (with food, y-), given that food was

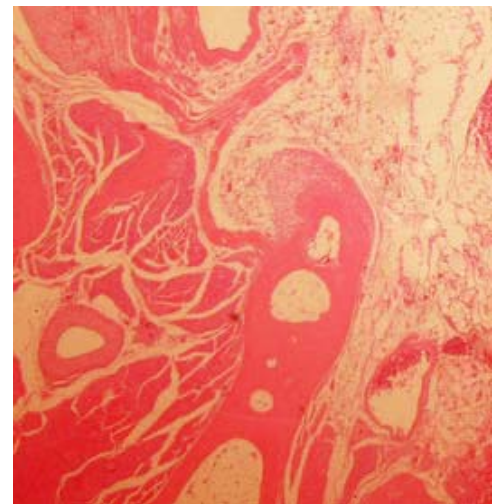


Figure 1 20 days post pinion. (400X)

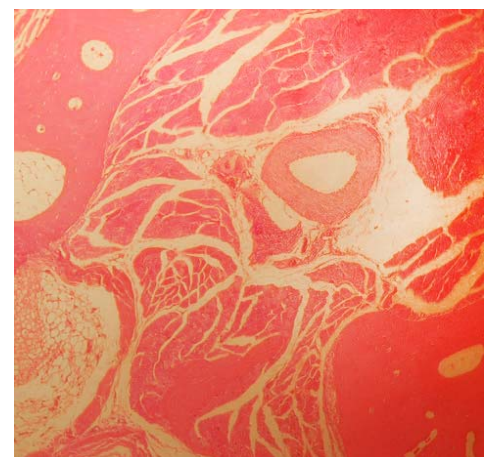


Figure 2 40 days post pinion. (400X)

period of time when a bird chooses to stay in bigger area(y+) or smaller area(y-).

Preference test 2 (Fig 4) showed that with enclosure being the same size and with food and perch available, the birds preferred to stay in the higher vertical space (y-) in comparison with the low vertical space (y+).

Analyses of birds' preference between space, food and altitude (Fig 5) indicated that the big space of sequence 1 (\bar{x} = 327.09 sec.) without food had higher mean value than sequence 2 (\bar{x} = 129.7 sec.) with smaller space and food. Sequence 4 (\bar{x} = 507.33 sec.) with altitude of 85 cm had higher mean value than sequence 3 (\bar{x} = 59.6 sec.) of 54 cm altitude.

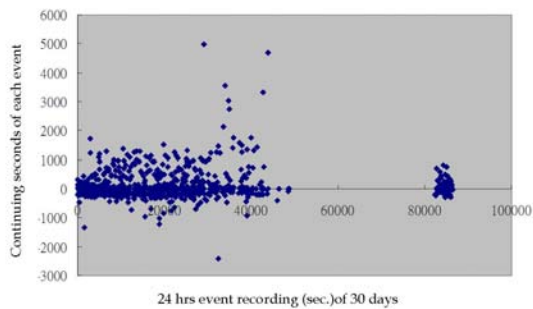


Figure 3 Preference test 1- Relationship between space and food against time

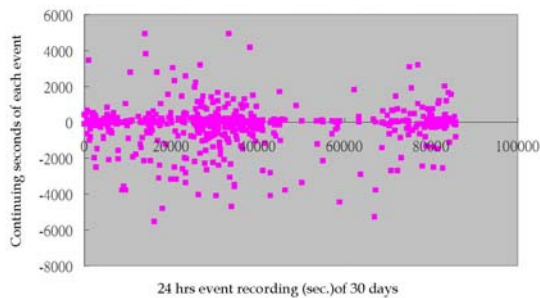


Figure 4 Preference test 2 - Vertical altitude effects on bird's time budget

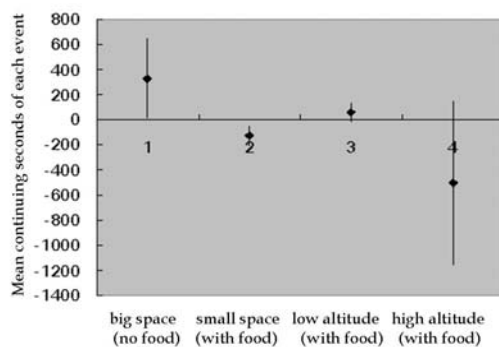


Figure 5 Analyses of birds' preference between space, food and altitude

Physiology study: A photo of the cross-sectional view of the breast muscle of one wild-caught great mynah at days 1 and 40 after flight restraint was taken. It showed that the pectoralis muscle significantly

diminished after 40 days of flight restraint (Fig 6). EMG performance was recorded using a 2mV continuing electric signal to stimulate the bird's breast muscle. To prevent birds from further and unnecessary electric stimulation, we only recorded the first and second minutes after the EMG signal. The same EMG test was applied to four birds to measure pectoralis muscle, but only one bird was physically restrained to get the data. The muscle strength decreased significantly after 40 days of flight restraint (Fig 7, 8). The first (1.506 : 0.177) and second minute (0.163 : 0.044) were measured with 0.01 volt.



Figure 6 Cross-sectional view of wild great mynah (left) after 40 days of flight restraint

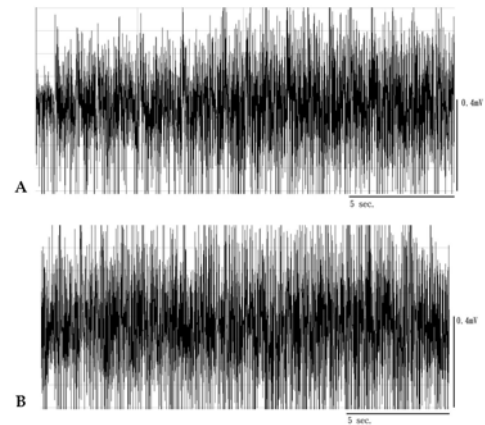


Figure 7A EMG showing wild caught birds at day 1 from 0 to 20 seconds **B** EMG showing wild caught birds at day 1 from 60 to 80 seconds

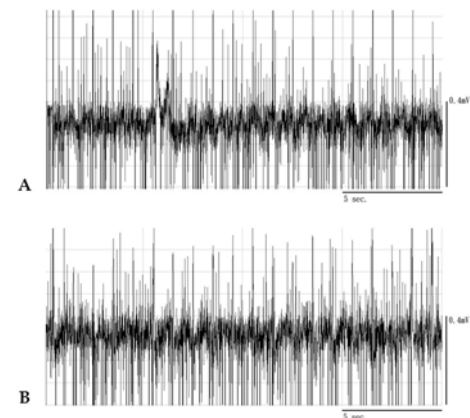


Figure 8A EMG showing birds at day 40 after flight restraint at 0 to 20 seconds **B** EMG showing birds at day 40 after flight restraint at 60 to 80 seconds

Table 1 Activity of wild-caught birds at day 1 from 0 to 60 seconds

ID	Time (sec.)	Activity (0.01 volt)
Ws1	0	1.506
Ws1	60	0.163

Discussion

Animals in captivity, under proper care and management, generally live longer and healthier than their conspecifics that have the freedom to live in their natural environment. They receive stable and sufficient food and water supply, veterinary attention when needed, protection from predation, and avoidance of inter or intra-specific conflicts (Mason, 2010). However, not all species adapt well in confined setting due to variation in susceptibility to stress and subsequent physical and psychological behavioral changes. Captive birds are often kept in confined cages or flight restrained through various procedures to restrict their ability to fly in open display areas such as in parks or zoos (Hesterman *et al.*, 2001). Scientific measurements and tools can be used to reveal how animals adapt and cope with their environment (Broom, 2006). As documented, the ability to cope is associated with behavioral, physiological, immunological and emotional components of the animal (Broom, 2011). However, there is limited information on captive bird's welfare, and whether or not flight is essential in the captivity. The present study was based on Broom's welfare methodology and theology, where animal welfare measurements, assessments, decisions and concerns were successfully documented and discussed. The present experiment examined the pathology, ethology and physiology methods to assess the welfare of captive birds. This information may assist in the understanding of animal welfare and point to new methods in the future.

The current study revealed that the formation of neuromas did not appear after 40 days of wing amputation. A study conducted by Cheng (2004) found that neuromas were formed between days 9 to 40 in beak trimmed hens. This result was seen in hens that constantly pecked food after beak trimming, causing friction around the debeak section. The existence of neuromas can be assessed as pain in physiological measures (Broom, 2007). However, in the pathology part of this study, the pinioned wings only had direct contact with the air, which potentially results in less friction and less pain and leading to better welfare and outcome.

The preference test revealed that the captive birds had motivation towards basic needs such as food and water. From the result, it is revealed that the amount of space does alter the birds' preference. The experiment showed that the birds preferred larger cages and higher vertical altitude cages compare to the smaller one. Similarly, Broom (2007) indicated that positive preferences by an animal were referred to as a good indicator of good welfare. Therefore, these preference test results should be incorporated into enclosure design, in order to provide captive birds with adequate space and to reduce stereotypic

Table 2 Activity of flight restraint birds at day 40 from 0 to 60 seconds

ID	Time (sec.)	Activity (0.01 volt)
As1	0	0.177
As1	60	0.044

behavior. Asher *et al.* (2008) also suggested that cage shape played an important role in determining the quantity of stereotypic behavior, especially in medium-sized cage. In addition, based on these findings, regulations on minimum enclosure size requirement in zoological and other similar settings may be established to improve animal welfare. Providing adequate space for flight and other natural behaviors may also prevent captive birds from showing fear and distress from over-handling and stress associated with visitors.

Although EMG is applied to test human muscle or nerve abnormality, as far as we know, it is the first time EMG was used as the indicator of muscle strength in captive birds. The results verify that the response of the pectoralis muscle to electric stimulation and the muscle quantity decrease along with the flight restraint of the experimental bird. During the study period, the birds' weight remained 5% different from its 1st day weight despite losing great amount of the pectoralis muscle at the end, indicating that flight restraint did not affect their basic survival needs as long as the birds were well fed. However, the preference test clearly responded to Mason's mink study (2001) that both birds and fur-farmed minks were still motivated to perform the same activities as wild animals. Access to the swimming pool (for minks) and being able to fly (for birds) rated as much the same by getting food. Most of all, we believe EMG could be a good tool to examine other captive animals muscle strength, especially wild-caught animals. It may serve as a good indicator to evaluate successful bird release or reintroduction rates of injured birds after long term rehabilitation.

It is highly debatable whether flight is essential in captivity. Hesterman *et al.* (2001) indicated that although defighting practice deprived birds of the natural behavior of flight, but then allow them to express other behaviors that would be otherwise suppressed in a confined setting. However, it does not equate to better welfare, as flight itself is beneficial to physical wellbeing of the birds as it provides cardiovascular exercise and prevents injuries when falling from high perches. Defighting practice may also cause irritation and elicit undesirable behaviors such as feather plucking and self-mutilation in birds. Engebretson (2006) also suggested that defighting a bird did not necessarily eliminate its natural instinct to fly, and it would usually attempt to fly once its physical ability regained. Therefore, defighting only alters their physical ability to fly, but not their interest in doing so. Our study also indicates that pectoral muscle strength rapidly deteriorates once the freedom to express natural behaviors is compromised.

The conclusion from this study is that despite the fact that companion birds or zoological birds have been captivated for generations, birds are highly inclined to fly as part of essential locomotion even though basic needs are provided. How birds are being displayed and how enclosures are designed should be considered carefully, especially the size and the vertical altitude of the cage, to allow birds to fulfill their needs to fly. This result coincides with Broom (2007), who stated that for an animal to cope, it implies that the individual has control of mental and bodily stability. Nonetheless, more bird samples are required for more reliable and significant results and further research is needed to conclude our study.

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