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Pain and distress in birds: literature review and practical application of evaluation tables

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“Bisogna tener presente che un animale, sotto molti aspetti, non soffre meno, ma più di noi.”

Konrad Lorenz

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ABSTRACT

Recognition of pain and distress in birds is a broad topic, which is still poorly investigated.

The aim of the study is to combine both literature and practical experience, in order to combine theory and practice.

This dissertation first tries to review different approaches in recognizing pain and distress in birds. In the second part gives an overview of data collected in the field during my practical activity at the rescue centre in Lazise (Lazise CRAS -Verona). Data collected regards three different birds' families: Passeriformes, Birds of prey and Waterfowl, which are the bigger families hosted at the rehabilitation centre.

Predetermined evaluation tables are used: containing a set of adjectives and features on birds' body to look for when approaching a bird in a situation of pain and stress.

Since multiple species of birds arrive at the centre and they come from different situation (some may be poisoned, others are injured or orphaned), the parameters have an individual variable.

Some considerations are then made, according to first data collected at the birds' time of arrival and the outcome after medical treatment and rehabilitation.

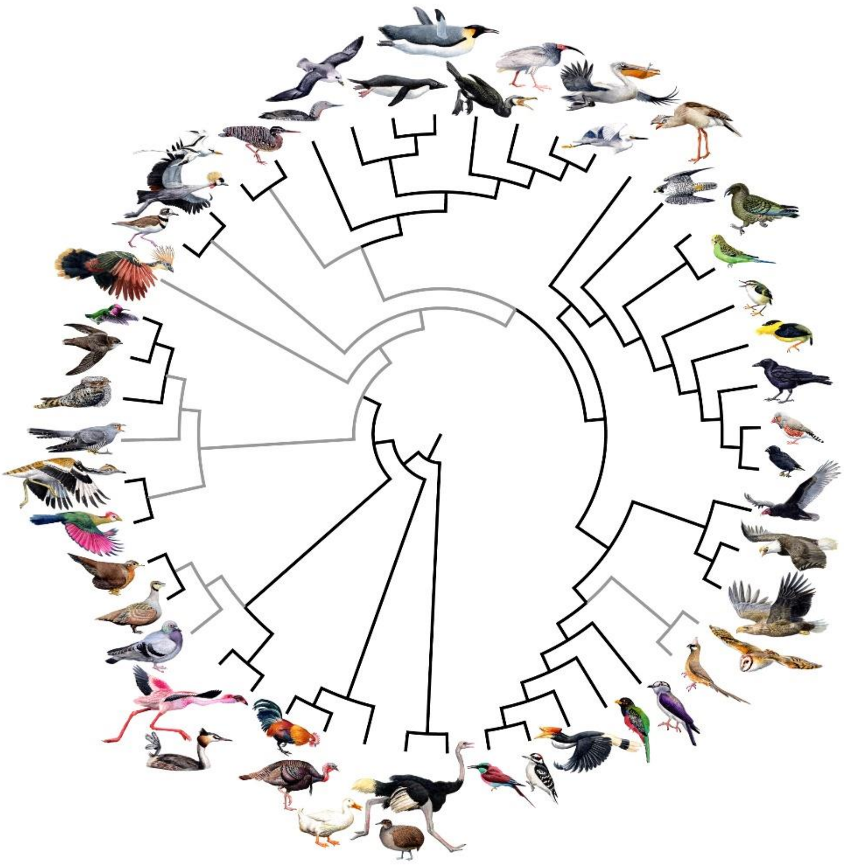
INTRODUCTION

Birds are one of the most incredible creatures on earth, possessing the ability to flight thanks to their unique physiological features.

This class comprehends about 10'000 species, each with their own appearance and habits.

They are widespread over all earth surface, ranging from North Pole to extreme South desertic areas and tropical forests too.

From the taxonomical point of view, all 23 birds Orders are included in the Aves class. Each Order share some similar characteristics and usually its Families inhabits areas with common climatic features.



Birds play a huge role in preserving our ecosystem and act as sentinels from the ecological point of view: spread seeds, are involved in the pollination of vegetable species and act as pests' control. In the last centuries, due to climate change and human activities, the number of birds' species has drastically declined, one in eight species are now threatened with extinction (State of World's Birds 2022).

The study of birds contributed on several aspects of biology, like Charles Darwin's studies on Galapagos' finches and the theory of origin of species through natural selection, studies on embryology and genetics and animal behaviour as well, thanks to studies of Konrad Lorenz and Nikolaas Tinbergen.

Birds are one of the most well-studied groups of animals, both from the anatomical and physiological perspective and the behavioural one.
It's known that are warm-blood vertebrates, possessing feathers all over the body and a four-chamber heart. They have modified forelimbs into wings and hindlimbs used to perch and grab items. Bones are very light and hollow, making them the perfect fling machine, also in combination with the air sacs and powerful muscles.
Most sense to which they rely on is vision, having the ability to control the pupil's dimension and eye's muscles contraction.
This assertation is also well supported by evidence that in most species of birds, relatively large portions of their brain are devoted to the analysis of information from vision (Graham R. Martin 2020).
However, vision can become secondary through a process of regressive evolution. At the same time other senses, like olfaction, hearing and touch sensitivity, can come to take on some of the primary functions usually carried out by the vision. These include food detection, predator detection and guidance of locomotion (Graham R. Martin, 2020).
In birds of prey, for example, olfaction and hearing have a key role which is complementary to vision, especially when it is time to find and ingest food items.
Each sensory performance has some limits that are defined as *absolute thresholds*: are the minimum amount of a stimulus that can be detected. Those thresholds usually do not provide clear-cut answers, mainly because thresholds differ between species and individuals, so most of the times results provided are a mean value taken by a sample of individuals.
Birds' ability to perceive chemical senses, useful in their daily life, comprehend three categories: chemesthesis (irritation and pain), olfaction (smell) and gustation (taste) (Larry Clark et. al.).
Chemesthesis is the perception of chemically induced pain, in which the first mediator of noxious stimuli is the nociceptor.
In the further reading of this dissertation the main nociceptive pathway and physiological process of pain will be deepen in order to better understand and evaluate birds pain expressions and how to handle it from a clinical point of view.

1. NOCICEPTIVE PATHWAYS IN BIRDS

First of all a distinction must be made among pain and nociception.

According to the International Association for the Study of Pain, pain is a sensory and emotional experience associated with actual or potential tissue damage. (Jamie M. Douglas et. al., 2018)

Nociception instead is intended as the whole process of detection of noxious stimuli by specialized peripheral sensory neurons which generates different physiological and behavioural responses.

Information about pain in birds is limited and has been derived from only a handful of species from the following orders: Anseriformes, Columbiformes, Galliformes and Psittaciformes.

Birds have neurologic components to respond to painful stimuli and endogenous antinociceptive (antipain) mechanisms to modulate pain. (Karen L. Machin, 2005)

Those neurologic components are nociceptors, specialized receptors sensitive to noxious stimuli.

The physiology of pain involves two processes: a peripheral process involving detection and transmission of information of a potential damage, and a central cerebral process to respond to this incoming information.

First step are primary sensory nociceptors connecting the internal body environment with the external one.

Their cell bodies are located in the dorsal root ganglion, a peripheral axon that innervates tissues, and a central axon that enters the spinal cord to transfer information to the CNS.

The major component of this system is the Trigeminal Nerve (TN) which is the primary sensory nerve of the head and code mostly for mechanical and thermal stimuli. (Larry Clark et. al, 2022)

The rest of the body is then innervated by the somatosensory system which code both for mechanical-thermal stimuli but also for chemical ones.

Most are unmyelinated C-type polymodal nociceptors with conduction velocities of 0.3–1 m/s. However, some myelinated A-delta high-threshold mechanoreceptors with conduction velocities of 5–40 m/s also respond to chemical stimuli.

Acute pain can affect both peripheral and central nervous systems, altering the sensitivity to stimuli. This phenomenon can be due to a lowering of activation threshold, persistent pain, hyperalgesia, or short response latency.

Peripheral sensitization result when noxious stimuli cause a drop in pH and release of inflammatory mediators, like histamines, to which unmyelinated C fibres are sensitive.

On the other hand, central sensitization occurs when the threshold required to activate the dorsal horn neurons decrease following nociceptor activity (Karen L. Machin, 2005).

a) MAIN NOCICEPTORS

Three types of nociceptors have been identified in birds:

- *High threshold mechanothermal*: polymodal receptors, respond to sudden rise in temperature and mechanical stimulation. Their impulse transmission is quite slow
- *Mechanical*: possess large receptive fields and information are transported through unmyelinated C fibers. Increasing the stimulus strength increase also the response.
- *Thermal*: either Aδ and C fibers. Have higher threshold for heat respect to cold, mainly because birds body temperature is higher.

b) PERIPHERAL NERVOUS SYSTEM

The Peripheral nervous system is composed of a set of nociceptors associated with primary afferent nerve fibres, usually unmyelinated C fibres which fire slowly but continuously, giving a generalized pain sensation.

The prolonged firing od C fibres causes a release of glutamate which then acts on N-methyl-D-aspartate receptors in the spinal cord and lead to central sensitization (Jamie M. Douglas et. al., 2018)

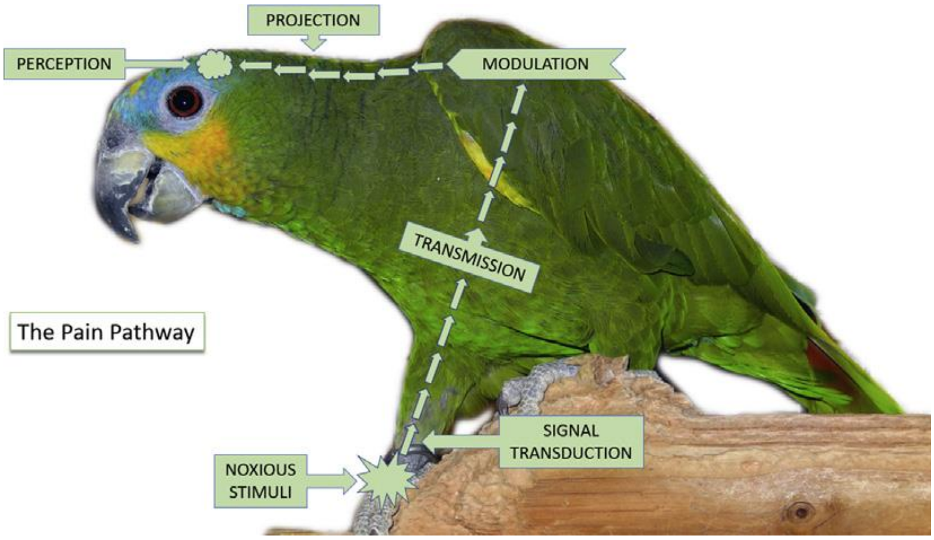


FIG 1. *Schematic illustration of the ascending pain pathway. A noxious stimulus at the periphery causes signal transduction at the nociceptor. The signal is transmitted along peripheral sensory axons to the cell body in the dorsal root ganglion, which then relays the signal to the dorsal horn of the spinal cord for processing, modulation, and projection to the brain along ascending spinal tracts. When nociceptive signals reach the brain, they are modulated and processed for cognitive and emotional perception.*

Birds also have other anatomical structures, the brachial plexus and the lumbosacral plexuses. They are composed by sympathetic nerve fibres that branches and innervates both trunk, legs and wings.

Are of relevant importance, because as in mammals, blocks of regional anaesthesia can be performed before surgery, allowing to desensitize the area.

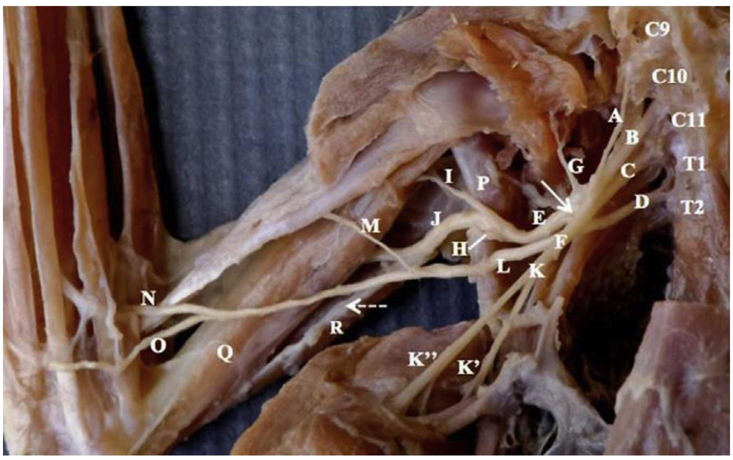


FIG 2: Anatomy of an avian brachial plexus. C9-10-11, T1-2 are ventral branches of spinal nerves forming a common trunk (arrow G). It branches in dorsal and ventral cord which innervates trunk, pectoral and wings' muscles.

c) CENTRAL NERVOUS SYSTEM

Pain signals are transmitted from receptors to several areas of the midbrain and forebrain by multiple ascending spinal pathways (Karen L. Machin, 2005). A peculiarity if birds is the absence of the cauda equina (organization of spinal nerves at the end of lumbar vertebrae) and the fact that all their vertebrae are fused into a single canal in which the spinal cord and spinal nerve pass.

During nociceptive processing, a cascade of events takes place that play a role in the experience of pain. These events trigger highly variable regions of the brain in the one that is called pain matrix. The pain matrix refers to the substrate that is significantly and actively modulated by a variety of regions and receptors in the brain, dependent on the precise interplay of factors contributing to an individual perception of pain. It has been well established that mammals possess areas in the brain required for the conscious perception of aversive elements associated with pain and birds likely have similar conscious experiences of the negative affective components of pain (Jamie m. Douglas et. al., 2018)

The structures of the brain involved in the complex affective processing of pain signals, however, are also those involved in the processing of other forms of complex information, including analysis of emotions unrelated to pain. That is why, considering this complex network a specific pain site has not yet been discovered.

Some scientific studies, however, have disclosed that perception of prolonged pain increase the glucose metabolism in some area of the brain rich of opioid receptors.

Those opioid receptors are controlled by the endogenous opioid system like endorphin and enkephalin that act on them thus modulating and inhibiting pain perception.

d) MOST COMMON ANALGESICS USED WITH BIRDS

Pain perception in birds is likely analogous to that of mammals, and invasive and painful procedures should always be accompanied by appropriate analgesia and anaesthesia (Karen L. Machin, 2014).

Proper husbandry like environmental settings with possibility of choice and location to perch, places to rest and hide, as well as food differentiation can make the clinical patient more comfortable for thew entire duration of recovery and rehabilitation.

When administering analgesics and drugs, genetic factors and species differences must be taken into account, some species may be more sensitive rather than others. This is the example of opioids, like Butorphanol which is the most used in bird's analgesia.
Is a synthetic antagonist of μ-receptors and strong agonist of κ-receptors, so it is considered the analgesic of choice, given that birds possess and higher proportion of κ-receptors compared to mammals. It is mainly used because reduces the anaesthetic concentration of Isoflurane by 25% (Reiner et. al., 1989).

In birds NSAIDs are preferred to corticosteroids, even if some studies reported renal toxicity after prolonged use. As in mammals, maintaining hydration when using them, may aid in the prevention of renal morbidity (Hassan et. al., 2011).
Most used are Ketoprofen and Meloxicam, always used in combination with opioids to obtain a more effective analgesia (multimodal analgesia).
Meloxicam especially is more used in the treatment of orthopaedic post-operative patients, where 0.5-1 mg/Kg is administered, according to species and veterinary indication.

For sedation and as premedication instead, α-2 agonists like Medetomidine, Dexmedetomidine or Xylazine are used. Following the anaesthetic protocol, they are always combined with an opioid and ketamine.
Their use alone, without multimodal approach is not used often as they provoke negative cardiovascular effect like hypotension and vasoconstriction and excessive sedation at high dosage.

Ketamine, even at low doses, may contribute to analgesia and anti-hyperalgesia by preventing NMDA receptor-mediated central sensitization. Therefore, it is useful for both pre-emptive and postoperative analgesia (Lamont et. al. 2000).

Local anaesthetics are provided during intra-operative procedure, especially Lidocaine and Bupivacaine which provide analgesia by depolarization of Na^+ channels and resultant conduction of pain. Although local anaesthesia is sufficient for pain relief, it does not reduce the stress induced by physical restraint and handling of an awake bird, so sedation or general anaesthesia may also be necessary.

In addition to pain relief for surgical intervention, anaesthesia is an important tool for stress reduction in birds thus, analgesia is indispensable in avian medicine for ethical reasons and also for psychologically improving the animal's ability to withstand the stresses associated with surgical recovery and disease conditions (Michael Lierz, 2012*)*.

2. BIRDS INTERNAL RESPONSE TO STRESS

The terms "stress" used in the avian world can have different meaning: 1) stimuli (stressors) that challenge the normal homeostasis, 2) the stress response to emergencies or 3) the chronic stress due to over activation of adrenocortical axis.

Birds, as all other animals, during their lifetime may be cope with some unpredictable perturbation which can alter their normal homeostasis and result in emergencies adjustment of physiology and behaviour. This response is mediated internally by the adrenocortical response which result in a rapid increase od circulating glucocorticoid levels (Julio Blas, Stress in birds, 2022).

All these changes in hormones have affect in the body by increasing cardiovascular tone, inhibiting digestion and other costly anabolic processes. But how can we detect those changes looking at the external phenotypic characteristics of birds?

There are some parameters, which precursor derive from observations and studies on laboratory animals, which can tell us how and in which degree a bird is coping with the stressful situation.

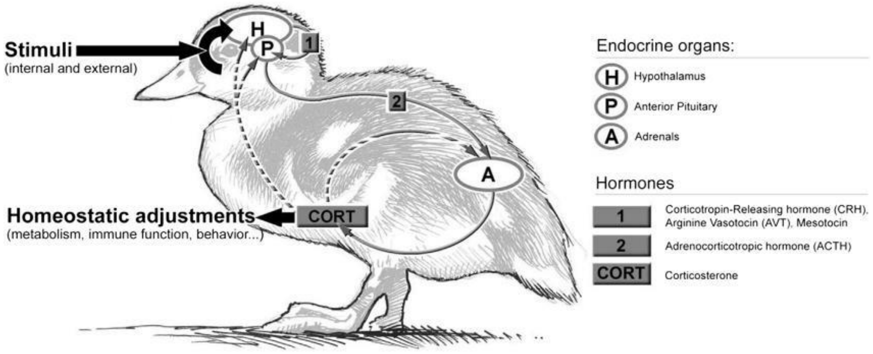


FIG 3: Adrenocortical response to stress. Following exposure to a stressor, the hypothalamus release hormones like CRH (Corticotropic releasing hormone) which stimulates the anterior pituitary to secrete in the blood circulation ACTH (Adrenocorticotropic hormone). This in turn stimulates the adrenal glands to secrete CORT (Corticosterone). CORT increase will promote physiological and behavioural changes.

3. PAIN ASSOCIATED BEHAVIOURS

Birds often do not indicate pain in an obvious manner because species that may be preyed on are less likely to display overt pain-associated behaviour that may attract attention from predators. Considerable variation in behavioural responses to pain may occur among avian species, breeds, strains, or individuals, and there is no reliable or universal indicator of pain. (Karen L. Machin, 2005).

Although there are no reliable or universal indicators of pain, birds tend to respond to noxious stimuli with a fight-or-flight response (escape reactions, vocalization, excessive movement) and/or conservation–withdrawal responses (no escape attempts or vocalization and immobility) (Wolley SC, Gentle MJ, 1987)

The main differences in the behavioural asset, between acute and prolonged pain, regards the body position taken by the animal and other measurable parameters. Acute pain, lasting from few seconds to days, result in active avoidance behaviour, comprehending vigorous escape attempts, vocalization, wind flapping and jumping, increased heart and respiratory rate, as well as increased blood pressure. In comparison, puffed-up appearance, inappetence and inactivity are shown when birds are in a situation of prolonged/chronic pain.

Grooming behaviour pattern can be an indicator of pain, especially when the sequence and frequency is disrupted or decreased. In chronic pain sings as over grooming, feather picking, and self-mutilation are noticeable (Gentle and Tilston, 1999).

Immobility in another complex reaction to painful or fear-induced stimuli, and according to some scientist it may be an evolutionary antipredator strategy to prevent further damage produced by attempts to escape (Gentle MJ, Hunter LN, 1990)

Behavioural responses to pain are complex, but pain-coping behaviour can be influenced by changes in the motivational state of the animal (Gentle & Tilston, 1999), so simply by changing its focus of attention/level of awareness. When placed in a novel environment, painful birds can appear normal and alert because attentional mechanisms are occupied with exploring a new physical and/or social environment (Gentle & Tilston, 1999).

4. PRACTICAL EXPERIENCE AT LASIZE RESCUE CENTER- CRAS

Birds represent the most abundant and diverse class of air-breathing vertebrates and their distribution and presence in each country is extremely diverse and wide.
In Italy, specifically Northern Italy the local avian fauna is composed of many Families and Species, but the most common ones are Birds of prey, Passeriformes and Waterfowl.
Those three big families are the main focus of the practical part of this dissertation, since they represent most of the bird species that arrive at Lasize rescue center CRAS.

The CRAS of Lasize is a rescue center for wild animals (CRAS: Centro Recupero Animali Selvatici) where volunteers rescue over 1200 animals per year, 77,5% of which are birds.

Among all the Passerines hosted at the rescue centre, blackbirds, starlings, jays, sparrows and finches are the most frequently present.
In 2021 s birds of prey arrived were mainly kestrels, buzzards, honey buzzards, scops owls, owls, hawks and a barn owl.
Herons, swans, mallards, coots and grebes are the most common waterfowl patients, hosted for rehabilitation and therapies.

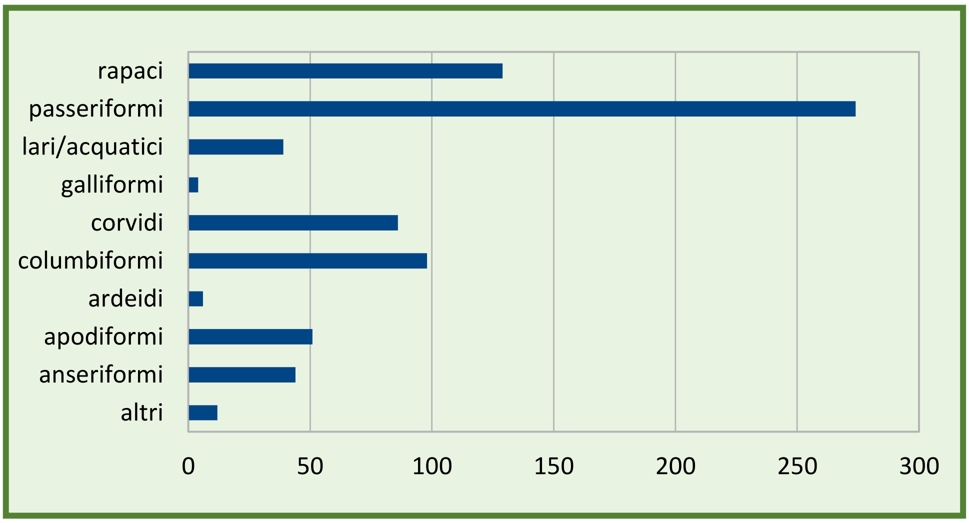


FIG.4: statistical analysis of major birds' families received at Lasise CRAS in 2021

Usually, these wild animals are brought in by private citizens, who must first provide the center's volunteers with an accurate description of the animal's situation and conditions. Through a general evaluation by phone call, the volunteer decides whether the animal requires veterinary assistance and hospitalization. This is because sometimes the animals are injured or in danger of life, it is therefore essential to intervene promptly. Other times instead they are young animals with their parents nearby who are doing their first flight tests on the ground. In these latter cases, private citizens are advised to observe the situation from a distance and not to intervene by touching the animal.

At arrival at the rescue center, the anamnesis of the patience is reported on special forms and in the meanwhile the animal is transferred in an adequate carrier, according to size of the animal and housing requirements.

Ordinarily all animals spend a period of time in a small carrier, at least until the veterinary visit. All carriers are kept in a quiet place and covered, to minimize the stress.

All new incoming birds are visited by the veterinarian in charge, who evaluates clinical condition, body condition score, hydration state, type and severity of injuries and the possible outcome, taking into account the actual and future quality of life of the animal.

Most of the time for a wild animal, being kept and treated for a long period of time and to be continuously handled by humans, could be a source of stress higher than the moment of injure/accident itself.

Treat and handle those situations, is not always an easy task.

That is the reason why a pre-formed table could be useful to evaluate the incoming patient, even when the veterinarian is not readily available, and primary therapies and analgesics need to be administered.

5. EVALUATION TABLES

Using pain scales requires an understanding of normal and pain-related behaviours for the species and individual. Pain score sheets can help maximize the efficacy of pain scoring using behavioural analysis. Score-sheet descriptions of behaviour must be refined, and terms must be clearly defined to reduce observer bias and interobserver variability (Michelle G. Hawkins, 2018).

According to two degree theses, respectively from the University of Milan and University of Perugia some studies and behavioural analysis were performed by observation of a group of hospitalized patients. Those birds were observed remotely, so that their behaviours could not be influenced by the human presence. At first a scale for the measuring of pain, containing adjectives and parameters useful for pain assessment was drawn up. In a second moment the same scale was used for an in-depth analysis of clinical patients.

The scale includes six categories:

1. Respiratory rate and pattern of respiration
2. Posture
3. Activity level
4. Eyes
5. General appearance
6. Sensory state (how an animal reacts to external stimuli)

CATEGORY	SCORE	INDICATORS
Respiratory rate and pattern of respiration	0	normal frequency, eupnoeic breath
	1	mild or moderate tachypnea (< 50%), eupnoeic breath
	2	mild or moderate tachypnea (< 50%), dyspnoeic breath
	3	severe tachypnea (> 50%) and/or dyspnoea
posture	0	normal and natural posture for species and age
	1	tense/ head on the body but still standing
	2	activity alternate with squatted
	3	majority of time is squatting, head resting on body
activity level	0	activity level, behaviours and vocalization are typical of the species and age
	1	show the normal degree of activity in a non-continuous way, alternated with guarding behaviours, hyperactivation or inactive attitude
	2	absence of normal activity and vocalization, explorative/guarding behaviour
	3	lethargic attitude
eyes	0	open
	1	open but guarding, alternation between open eyes and blinking
	2	alternation between open eyes and blinking to semi-closed eyes
	3	semi-closed or closed
general appereance	0	normal plumage
	1	puffed up or ruffled plumage, horripilation
sensory state	0	normal reaction to stimuli and explorative behaviour common of the species
	1	hyperreaction to stimuli/ reduced explorative behaviour
	2	delirium/obtundation
	3	severe obtundation

The score goes from 0 to 16, where 0=absence of pain and 16= maximum pain perceived.

Depending on the result obtained, the analgesic plan is decided.

a) PRACTICAL USE OF SCALE IN BIRDS OF PREY- BUZZARD

This specimen of buzzard (Buteo buteo) was hospitalized because it was found on the ground, helpless and unresponsive. At the time of hospitalization was reported that it had already been on the ground for two days. After a careful examination of the plumage to evaluate any signs of hunting, we proceeded with the examination of the bone structures which appeared intact. However, once the animal was placed in the carrier, it did not regain an upright posture but lay on its back.

No sign of impact or cranic trauma were present, pupils were both reactive to light stimulation.

Respiratory rate was slightly increased, and normal activity and explorative behavior were almost absent

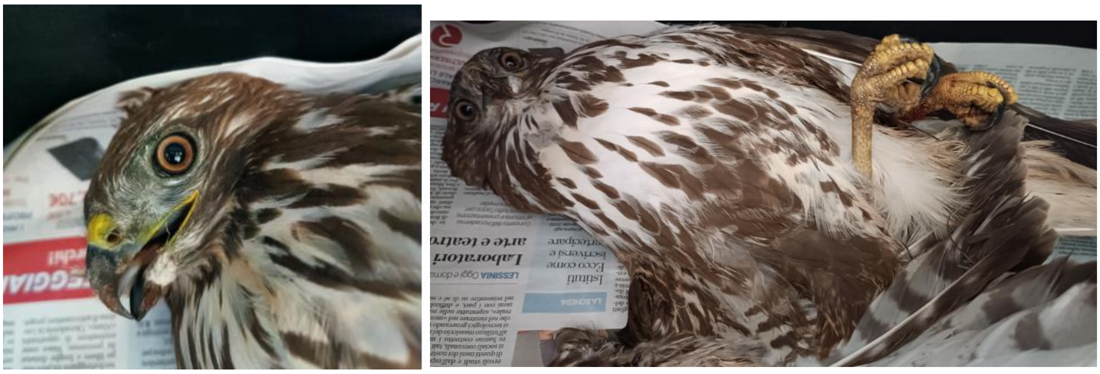


FIG 5-6*: responsive and open eyes, on the right its recumbency on the back*

The diagnosis was a severe infected lesion at the level of the tarsus, with necrotic tissue and myiasis, probably a secondary consequence ischemic necrosis. The limb no longer had proprioception and was unresponsive to reflexes.

Using the scale shown before, an overall result of 9 points.

Given the seriousness of the lesion and the fact that the limb could not then regain the functionality necessary for the normal behavior of the species, the buzzard was euthanized.

b) PASSERINES- SONG THRUSH

***FIG** 7: unresponsive and lethargic state at arrival time at the rescue center, before analgesia*

A specimen of song thrush, hospitalized at the CRAS following predation by a cat.

At the time of arrival, it was dyspneic with crouched posture, beak open and eyes closed.

After palpation of bone structures, no evidence of fracture was detected.

Final score following the evaluation table was around 12 points. An immediate analgesic therapy with opioids and antibiotics was administered but after half an hour the animal is deceased.

Despite prompt treatment after the assault and attempts to reduce the pain, too much internal damage had probably been caused.

c) WATERFOWL- HERON

This heron was hospitalized following multiple attempts to capture it. It presented an exposed fracture of radius-ulna, later confirmed by the X-Ray.

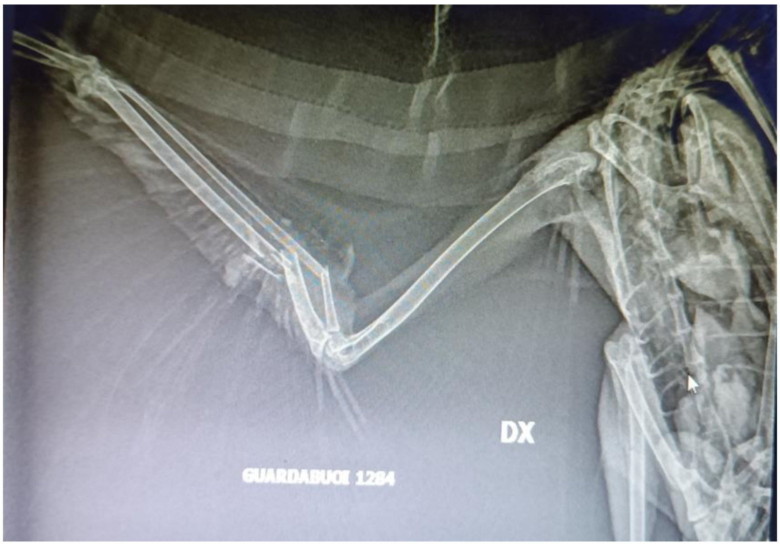


FIG 8: X-ray performed in a waterfowl heron reveals the entity of the injury.

The birds appeared responsive, with slightly accelerated respiratory rate, most probably due to capture, transport and pain.

The overall score was 5, and considering the state of the injury, it was probably not so recent.

An NSAIDs (Meloxicam 1 mg/kg), combined with antibiotic (Enrofloxacin 15 mg/kg) was firstly administered. In second step an opioid (Buprenophine) was added.

After veterinary evaluation of the X-Ray and future possible rehabilitation, a surgery was performed to reconstruct the fracture edges.

Anaesthesia was mask induced with isoflurane and then the heron was intubated. After surgery, it was placed in a hot-cage with UV-lamp to recover from the anaesthesia and an hour after it, was standing still.
Due to the fact that the fracture was exposed, a double antibiotic therapy was settled up, his food intake monitored daily and also its behaviour.
Pain assessment was performed daily, especially in the early days after surgery, in order to adjust analgesia management.

FIG 9: Heron two days after surgery.

Even if it seemed stressed by the temporary housing and daily manipulation for administration of therapies, the scoring of following days reported at maximum 2 points out of 16.
Following a period of about 3-4 weeks, a control X-Rays is performed and the formation of bone callus between fracture’s fragment was assessed.
After successful outcome, it was transferred into a bigger enclosure to regain muscles and strength to be released back in nature.
In those cases of long rehabilitation, animals are housed in carriers for long period of time, so its essential to monitor daily their food intake, faeces production and appearance, behaviour and wound healing process.
Another fact to consider before releasing back into nature is the BCS score, in birds evaluated with the pectoralis muscles’ shape.

CONCLUSIONS

Understanding pain pathways and applying a multimodal, pre-emptive approach to pain management in birds will benefit the patient. Likewise, identifying pain-related behaviours is important so that patients can be evaluated at the arrival time in the clinic and re-evaluated periodically. Pain evaluation and management are inextricably linked.

At an ANZCCART conference,10 examples taken from clinical avian medicine and surgery, research and teaching scenarios were presented, and the audience asked to score out of 10. (Brett Gartrell, 2017) Most of the people involved scored each scenario comparing it with humans, thus anthropomorphizing the perception of pain.

Therefore, it is of vital importance to not underestimate pain in birds and to observe carefully all possible sign which indicate suffering and distress. It is also important to not anthropomorphize any situation and maintain a critical approach when facing suffering birds.

Only by controlling pain, then stress can be reduced, and improving this sequence of action birds' welfare can be achieved.

Further improvement and acknowledgment of avian pain are still to be made, scientific studies both on anatomy and physiology on birds' perception are going on, essential is to apply what we have until now on clinical cases.

Even the smallest observation and trick can be of vital importance for a single patient, and it is our ethical responsibility to do the best we can.

The scoring system applied represent a useful tool to be used in the clinical setting. For personnel involved in the clinical field, knowledge of the species, normal behaviour and species susceptibilities and peculiarities are of relevant importance.

To evaluate every single animal hosted in a facility may seem time consuming, but an animal that is in good shape, has no pain signs and has recovered fully from rehabilitation, has major probability to survive once released.

Quality of life and probability of success when set free must be always taken into account.

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