Pain in Birds

The Anatomical and Physiological Basis

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KEYWORDS

- Avian • Pain • Nociception • CNS • PNS

KEY POINTS

- Three types of nociceptors have been identified in the avian peripheral nervous system: high-threshold mechanothermal nociceptors, mechanical nociceptors, and thermal nociceptors.
- The C and Aδ nociceptor axons are located outside of the spinal cord at the dorsal root ganglia, where they bifurcate into peripheral and central branches, terminating at the nociceptors and the dorsal horn of the spinal cord respectively.
- The spinothalamic tract is the most significant sensory pathway for transmission of nociceptive signals including pain, temperature, and light touch, whereas the propriospinal tract is responsible for segmental reflexes.
- Pathway tracing and behavioral studies determined that visual, auditory, and somatosensory input goes from the thalamus to the striatal region in the avian brain, regions that carry out the same type of sensory information processing that is performed by the mammalian neocortex.
- Opioid receptors and related endorphin systems in normal physiologic functions are complex and also modulate pain. Information regarding distribution and structure of opioid receptors indicates differences among species.

INTRODUCTION

As defined by the International Association for the Study of Pain, pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage.[1] The emotional aspect of pain makes the sensation different from the classic senses, which are primarily informative in nature. The emotional aspect of pain also is difficult to measure in animals because they cannot verbally describe their discomfort. The

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communication barrier between veterinarians and animals leaves practitioners to rely on behavioral observations to determine the presence of pain in their patients. For bird patients, assessment of pain can be particularly challenging. Avian species are predisposed to disguising pain, a survival mechanism that prevents unwanted attention from predators[2] and masks inferiority in instances of interspecific and intraspecific competition.[3] Instead, nociception, a process defined as the detection of noxious events by specialized peripheral sensory neurons found in the skin, muscle, joints, bone, and viscera of all vertebrates,[1,4] can be measured indirectly. Nociception generates a variety of physiologic and behavioral responses.[5]

Much of the information related to avian pain has been extrapolated from mammals, although significant avian-focused research has been published that illustrates anatomic and physiologic differences (**Fig. 1**). Despite some differences, birds possess the neurologic components necessary to respond to painful stimuli and they likely perceive pain in a manner similar to mammals.

PERIPHERAL NERVOUS SYSTEM

Noxious stimuli, events that damage or threaten damage to tissues,[1] are initially detected and encoded via nociceptors present in the avian peripheral nervous system (PNS). Largely, nociceptors are nonselective, gated cation channels, opening or closing in response to temperature, chemical ligands, or mechanical shearing forces.[6] When activated, nociceptors lead to a local depolarization of the terminal to initiate a conducted action potential. The nociceptors are associated with primary afferent nerve fibers. C fibers are the majority of the nerve fibers found in birds and are responsible for slow, diffuse pain that caters to a more diffuse, generalized pain sensation.[7] In contrast, the Aδ fibers are largely responsible for sharp, momentary pain and provide the precise localization of noxious stimuli.[7] C-type axons in birds have a conduction velocity of 0.3 m/s to 1 m/s, in contrast to a conduction velocity of 5 m/s to 40 m/s in the avian Aδ-type axons.[8] Slower conduction speeds in avian nerve fibers compared with the mammalian fibers are explained by smaller diameters and thinner myelin sheaths (when present).[9] Prolonged firing of C-fiber nociceptors in mammals causes release of glutamate, and this is assumed to be similar in birds. Glutamate then acts at *N*-methyl-D-aspartate receptors in the spinal cord and can lead to central sensitization.[10]

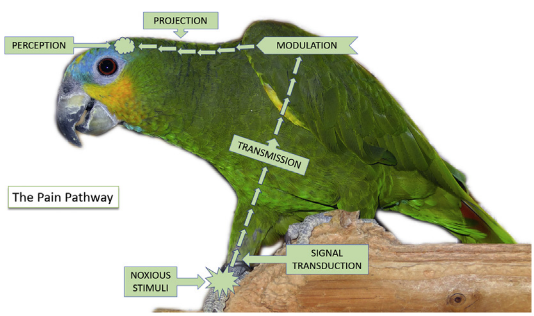

Fig. 1. Schematic illustration of the ascending pain pathway. A noxious stimulus at the periphery causes signal transduction at the nociceptor. The signal is transmitted along peripheral sensory axons to the cell body in the dorsal root ganglion, which then relays the signal to the dorsal horn of the 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. (*Courtesy of* Jamie M. Douglas, DVM, MS, Sacramento, CA.)