Horses are Obligate Nasal Breathers: But does this Obligation Still Apply when a Horses 'Nasopharyngeal Air Supply' and with this its 'Defence through Flight', is Compromised

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Abstract: It had been suggested that obligate nasal breathing had evolved to enhance a horses ability to detect predator scents whilst grazing. The singular opening of the vomeronasal organ into the nasal cavity had certainly developed in a manner that supported this form of breathing and thence theory. A horses ability to carry feed in its mouth, without this being drawn into the airway during flight, was another theory put forward to explain this obligation.

The horse as a species is heavily reliant on flight as a means of defence and thence survival. Any reduction in nasopharyngeal patency would logically compromise a horses ability to maintain acceleration and thence its ability to evade a predator. The likelihood that a horse would elect to supplement a compromised nasal air supply with orally inspired air whilst fleeing a predator, seemed logical. Nasopharyngeal and upper tracheal intraluminal pressure measurements recorded during periods of intermittent dorsal displacement of the soft and experimentally induced palatal instability indicated that air was being acquired orally in these situations.

Keywords: Palatal instability, mouth breathing, oropharyngeal seal, palatal instability, dorsal displacement of the soft palate.

INTRODUCTION

Strict nasal only breathing had been described as a physiological obligation or predisposition in the equid [1]. It had been suggested that this evolutionary development was linked to a horses need to detect predator scents whilst grazing [2]. More recently it had been proposed that this functional division of the digestive and respiratory components of the pharynx, acted to prevent any feed present within the buccal cavity being drawn into the horses airways during flight [3].

Historically obligate nasal breathing was thought to be achieved primarily through the positioning of the free border of the soft plate beneath and in intimate contact with the epiglottis [4,5]. More recently an additional mechanism to assist in maintaining ventral positioning of the soft palate within the nasopharynx was postulated. An oropharyngeal seal OPS, formed when air was vacated from the oropharynx during a swallow (deglutination) cycle, prevented the dorsal movement of the soft palate within the nasopharynx. The isthmus faucium formed the rostral valve of this seal and the intrapharyngeal ostium the caudal [3].

In normal circumstances a horse would not breathe orally although once the palate was displaced dorsal to the epiglottis it was certainly capable of doing this. Researchers suspected this occurred during periods of intermittent dorsal displacement of the soft palate IDDSP [1,6,7]. Billowing of the cheeks about the bit during expiratory efforts whilst the palate was displaced all but confirmed the oral passage of air [8]. It had also been postulated that when air entered the oropharynx (via the mouth) during periods of palatal instability PI [9,10], that it could then be drawn past the free border of the soft palate lateral to the epiglottis and into the airway [3,11]. This air would need to course around the aryepiglottic folds before entering the larynx which could then contribute to their being drawn medially [12]. Medial or axial deviation of these folds ADAF [13] had also been reported subsequent to the dorsal and caudal movement of the epiglottic apex during episodes of PI. This change in position resulted in slackening of the folds which could then be drawn into the laryngeal lumen during inspiratory efforts [10,14].

MATERIALS AND METHOD

To review the literature, to investigate theories as to why the horse had developed as an obligate nasal breather. To review situations where this obligation may have been overridden. To review any dynamic dysfunctions of the upper airway that could trigger the oral intake of air. To examine the potential deleterious consequences of the oral intake of air during exercise.

RESULTS

It had been suggested that obligate nasal breathing in equids had developed to assist in the detection of

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predator scent whilst grazing [2]. Others senses such as vision and hearing were also highly developed to aide in the detection of predators [15,16]. Certainly olfaction and in particular the use of the vomeronasal organ, which is employed to detect both pheromones and individual animals scents which include those of predators, plays an important role [17]. The fact that in the horse this organ communicates exclusively with the airway, rather than airway and oral cavity which is the case in other species, suggests a heightened role in predator detection whilst grazing [17,18]. Interestingly though in cattle which are also both prey animals and grazers, this organ which is again employed in part for predator scent detection, also communicates with the mouth. Cattle however are not obligate nasal breathers although they mostly breathe nasally [19].

Horses spend between 10 and 17 hours a day grazing which is broken up into 15 to 20-minute periods [20]. During these periods, when the horse's head is at ground level, its field of vision is partially obscured by its own body mass and any undulations in the topography. Sight is also being employed to assist in the selection of grazing material. At the same time olfaction plays a role in feed selection and in taste or flavour differentiation [21]. Nasal breathing, as is the case with most mammalians including humans [22], is employed exclusively whilst masticating.

Once a horses head is raised their field of vision is maximised and olfaction can be more specifically employed to detect predator scents. With the head raised flehmen behaviour can be employed to concentrate any scent, which then increases the likelihood of a predator being detected [23,24]. During a flehmen incident a horse will hold its breath while the air sample is being analysed. This behaviour would not be appropriate whilst a horse was in flight, when breath and stride are linked and longer periods of breath-holding are counter productive.

Smell is also employed in detecting predators in a number of other species including rats, mice, voles, deer, rabbits, gophers, hedgehogs, possums and sheep [18], however of these only rats, mice and rabbits are obligate nasal breathers.

Horses use flight as their main means of defence while deer species such as the mule deer which are also prey animals and grazers, use herding and aggressive behaviour and not flight as their main defence mechanism against predators [25]. They are not obligate nasal breathers and have a vomeronasal organ that communicates with both their mouth and the the nares [25,17]. Similarly cattle which use their numbers and aggression to defend themselves rather than flight, are not obligate nasal breathers and also have a vomeronasal organ that communicates with both buccal and nasal cavities [17].

In the equid there were occasions when air was assumed to pass orally, which included yawning (inspiratory) [26], coughing (expiratory) [27] and during periods of IDDSP [1,6,7]. Measurable reductions in nasopharyngeal inspiratory pressures during periods of IDDSP suggested that air was also being acquired orally [28] and this in addition to the previously reported oral passage of air during the expiratory phase of IDDSP [1,6,7].

PI was induced when the rostral valve of the OPS relaxed or opened. Air then entered the oropharynx from the buccal cavity. The soft palate could then move dorsally precipitating a narrowing of the nasopharyngeal airway. This air could then potentially be drawn past the free border of the soft palate, in the region the aryepiglottic folds, and into the airway [3,11]. A study into the effects of bilateral tenectomy of the tensor veli palatini muscle, which artificially induced PI, resulted in an increase in tracheal inspiratory negative pressures whilst nasopharyngeal negative pressures decreased [29]. The only rational explanation for the decrease in nasopharyngeal pressures was that there was another source of inspired air. The oral route was the only other option.

If air was being drawn through the buccal cavity and oropharynx and then into the airway during inspiratory efforts (mouth-breathing), it is highly likely that material such as oral dwelling bacteria, squamous epithelial cells, micro feed matter and saliva would accompany it. Indeed oral dwelling bacteria, squamous epithelial cells and feed matter are not uncommonly detected in tracheal aspirates and bronchoalveolar lavage BAL samples [30]. However these are normally dismissed as being contaminants of the collection process [30]. In contrast a human study into the influence of the collection process on bacteriological findings found that the passage of the bronchoscope did not significantly influence results [31]. Subclinical microaspiration in humans along with dispersion along contiguous respiratory mucosa are thought to be the main source of bacteria in the airways of healthy individuals [31]. These are in the main derived from the oropharynx or in some instances low grade gastro-oesophageal reflux [31]. With the OPS mechanism in place in the equid, microaspiration should not be an influencing factor when interpreting airways samples. This is of course unless there is a disruption of the seal during exercise which does occur during periods of PI and IDDSP. It had also been reported that emerging data supported a role for chronic microaspiration in some forms of pulmonary pathology [32]. A possible relationship between the chronic microaspiration of oral material during periods of PI and DDSP on the linings of the nasopharynx, larynx and major airways had been suggested but not yet investigated [3]. However a statistical association between PI and inflammatory airways disease IAD in sports horses had been demonstrated [32]. Another study in trotters found that in 42% of the DDSP afflicted group, a syndrome of tracheal inflammation STI was evident and that 71% of this group had bacteria isolated at greater than10(5) CFU/ml [33].

DISCUSSION

Horses, cattle and deer are all prey animals and spend large parts of their day grazing. Cattle and some deer species use herding and aggression as their primary means of defence whilst a horses defence is ostensibly based on flight. Cattle and deer are not obligate nasal breathers whilst horses are. An association between obligate nasal breathing and flight could be explained through the need for a horse to be able to flee immediately when a predator is detected. Unmasticated grasses could be carried in the buccal cavity without these being drawn into the airways. Masticated boluses present within the oropharynx would be swallowed [3].

The often accepted theory that this form of breathing had developed to aide in the detection of predator scent [1,2] was supported by the presence of the ‘nasal only’ opening of the vomeronasal organ, however this organ and its associated flehem behaviour was better employed in the stationary animal rather than during flight. Cattle and deer also employ this mechanism but are not obligate nasal breathers. Flehem behaviour also necessitates breath-holding, longer periods of which would be counter productive when attempting to flee a predator. During flight a horses panoramic vision along with its ability to detect sudden movement would play a major role in predator detection. Certainly the horses unique nasal only access to the vomeronasal organ, whilst in deer and cattle oral access was more efficiently employed, could be viewed as an adaptation in this flight animal. However the question that then arises is, did obligate nasal breathing evolve to enhance olfaction which is suggested by this vomeronasal anomaly [2], or did this anomaly develop as an adaptation better suited to obligate nasal breathing. Because this adaptation is unlikely to be efficiently utilised during flight, which is of course the horses main means of defence, its physiological obligation to breathe nasally [1] might be better viewed as a mechanism to prevent contamination of the airways with feed during flight in an animal that is a frequent grazer.

The widely accepted view that a horse does not breathe in any manner other than nasally needs to be reconsidered. Tracheal and nasopharyngeal airway pressure studies in horses experiencing clinical episodes of IDDSP [1,6,7] and experimentally induced PI [29] suggest the passage of air orally during inspiration (mouth-breathing).

In these situations the potential for oral material to contaminate the airways warrants investigation. In the future some instances of bacterial infections and IAD may be viewed as symptoms of an upper airways dysfunction rather than being primary lower airways conditions.

Most importantly the notion that a horse experiencing a dynamic depletion of its normal nasal supply whilst fleeing a predator, which is the case with IDDSP and PI, would not choose to supplement this depleted supply with air acquired orally, needs to be revisited.

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