Effect of Subcutaneous Mn and Cu Supplementation on Vickers Hardness of Osteons from Antlers of Red Deer.

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Deer antlers are bone structures composed of osteons [1] that grow and cast every year. Conventionally, hardness around osteons (microhardness) has been used in internal bones to evaluate the effect of an implant on the nearby bone matrix [2], tissue condition [3], osteoporosis [4], osteoarthritis [5], and mineralization [6]. Although microhardness affects the mechanical properties of bones [7], data on microhardness of deer antler are scarce. In fact, there is only one study [8] that establishes a relationship between microhardness and Young’s modulus of antler (stiffness). In contrast, other mechanical properties of antler bone material, such as Young’s modulus, bending strength, work to fracture, or impact energy have been shown to correlate with bone mineral composition [9-11]. Thus, for example, Potassium (K) content of antler has been inversely related to Young’s modulus [9]. However, the greatest effect so far corresponds to Manganese (Mn): a reduction in Mn linked to an unexpected cold period at the end of winter [10] reduced impact energy, whereas Mn supplementation increased it [11]. Supplementation of other minerals can affect the mechanical performance of the whole antler not by changing the mechanical endurance of the bone material, but through an increase in the thickness of cortical wall. Such is the case of Copper (Cu), which tended to increase the cortical thickness in antler from adult deer [12]. Despite the importance of Mn and Cu in bone metabolism [13], there are no studies concerning the effects of supplementation with Mn and Cu on microhardness of osteons from antler deer. Thus, this study tested the hypothesis that subcutaneous injections of Mn (weekly 5 cm²/100 kg body weight, BW) and Cu (each 42 days 1 cm²/30 kg BW) during the whole antler growth period, could increase the Vickers hardness (VH) of osteons from antlers of 40 yearling (1.5 ± 0.1 yr) and adult (4.0 ± 1.6 yr) red deer. Additionally, the effect of the physiological effort along the antler expressed as the difference of VH of osteons between the top and the base of the antler (as percentage) was also studied. The feeding program (composed by the diet and the unifeed ration) was the same for all animals and the same as used by Gambin et al. [12], that met or exceeded the nutrient requirements of adult male cervids (including allowance for antler growth) according to their BW during the whole experiment [14]. The effect of mineral supplementation on microhardness of adult antlers was analysed in 4 positions from the base to the top along the antler beam as indicated by Landete-Castillejos et al. [10]. Antlers from yearlings included only 2 sampling sites from the base to the top (burr and second third of shaft) due to their smaller size as proposed by Cappelli et al. [11]. Microindentations were made in the middle of cortical bone of antler using a controlled load. The interaction between Mn supplementation and antler position was not significant for adults. In fact, Mn supplementation did not influence on VH of antlers but VH tended (P = 0.06) to decrease from burr (base) to the base of the crown (near top). However, an interaction (P = 0.04) between Mn supplementation and antler position was detected for yearlings. In this case, VH decreased along main beam (from burr to the second third of shaft) in the control group but remained stable in the Mn group.
For Cu, a significant interaction ($P = 0.049$) was detected between supplementation and antler position for adults but not for yearlings. The VH tended to increase ($P = 0.08$) with Cu supplementation, but it was not influenced by antler position in younger deer. In older deer, the VH remained stable throughout the antler in Cu treated group but decreased from burr and first third of shaft to the second third of shaft and the base of crown. The difference in microhardness between the top and the base of the antler was affected by Mn supplementation in yearlings and adults but not by Cu supply at any age studied. The VH decreased in both groups, but the decrease was greater for control than for Mn deer for yearlings (-9.9 vs. -0.9%; $P = 0.03$) and for adults (-18.9 vs. -1.6%; $P = 0.03$). In conclusion, the VH is clearly affected by Mn and Cu supplementation in adult red deer and especially so in yearlings. In addition, Mn supplementation reduced the effect of physiological effort (expressed as percentage) on the VH of osteons from antlers in yearlings and adults, while the Cu supplementation reduced the effect of the physiological effort on the VH only when data from upper sections of the antler were considered. There is a possibility that Mn and Cu supplementation in humans could also improve the VH of osteons.

References