CORROSION OF BONE BY SOLUTIONS SIMULATING RAPTOR GASTRIC JUICE*

by
J. H. Cummings, G. E. Duke, and A. A. Jegers
Department of Veterinary Biology
College of Veterinary Medicine
University of Minnesota
St. Paul, MN 55108

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ABSTRACT. To determine whether falconiforms digest the bones of their prey more thoroughly than strigiforms because of greater gastric acidity in falconiforms, mouse bones were incubated in solutions simulating gastric juice from the two orders. Solutions simulating the gastric juice of falconiforms with a pH of 1.66 corroded bones more extensively than solutions simulating strigiform gastric juice with a pH of 2.35. Pepsin, at concentrations ranging from 0 to 4 mg/ml, also were slightly involved in bone corrosion at both pH's.

Introduction

Previous studies have shown that hawks digest bone more exensively than do owls (Errington 1932, Glading et al. 1943, Clark 1972, Duke et al. 1975). Duke et al. (1975) found that the gastric juices of hawks and owls had approximately equal proteolytic activities, but that hawk gastric juice had a much lower pH than that of owls. They hypothesized that the difference in acidity may account for the greater corrosion of bones that occurs in the stomach of hawks. The purpose of this study was to test this hypothesis.

Methods

To simulate gastric juices of falconiforms and strigiforms, two liters of Avian Ringer's solution were treated in the following manner. Using concentrated hydrochloric acid, one liter was adjusted to pH 1.66 and the second liter to pH 2.35, the mean pH's of samples of gastric juice collected preprandially from several species of hawks and owls, respectively (Duke et al. 1975). Solutions containing 4 mg/ml of bovine pepsin were prepared from aliquots of the Ringer's solutions, and the aliquots were readjusted to their respective pH's. This concentration of pepsin approximates the proteolytic activity of raptor gastric juice (Duke et al. 1975). Aliquots of these latter solutions were then diluted to a concentration of 2 mg/ml of pepsin using the Ringer's solutions with pH's of 1.66 and 2.35. This procedure provided three solutions at each pH containing (1) 4 mg/ml of pepsin, (2) 2 mg/ml of pepsin, and (3) no pepsin. Five experiments were performed using the latter two solutions, and six experiments were run using the solution containing 4 mg/ml of pepsin (table 1).

In each experiment, bones from 3 adult laboratory mice (*Mus musculus*), cleaned of tissue by a dermestid beetle colony, were used. The cleaned bones were washed in cold water, oven-dried, and divided into 2 groups: group A contained 1 femur, 1 scapula, 2 ribs, 2 each of caudal and lumbar vertebrae, and 1 tibia fibula; group B contained 1 humerus,

one-half mandible, 1 os coxae, 2 ribs, and 2 each of caudal and lumbar vertebrae. Each group of bones was weighed on a numbered, preweighed filter paper, and bone weight was calculated. In order to minimize differences in degree of digestion due to variation in bone size and shape, bones from each group were added to duplicate, numbered 100 ml aliquots of each of the six solutions (table 1), and the solutions were incubated for 4 hours in a heated waterbath at 39°C (the approximate body temperature of hawks and owls as determined in our laboratory). After incubation, the remaining bones in each group were collected on their corresponding numbered filter papers (see above) by filtration. Filter paper and bones were dried at 60°F overnight and weighed. The weight of the paper plus bone was subtracted from their initial weight after drying to estimate the amount digested.

To determine if incubation or the presence of bones in the solution may have altered the proteolytic activity of the solutions with 4 mg/ml of pepsin, proteolytic activity was determined in the solutions at each pH (1) before incubation or the addition of bones, (2) after 4 hours of incubation with no bones added to the solution, and (3) after addition of bones and 4 hours of incubation at 39°C. The release of tyrosine from hemoglobin upon addition of hemoglobin to the simulated gastric juice solutions was used as a measure of proteolytic activity of the pepsin in the solutions. Tyrosine release was determined by a modified colorimetric method (Duke et al. 1975).

Results and Discussion

Solutions of pH 1.66 corroded bones significantly more than solutions of pH 2.35 (table 1) at all pepsin concentrations. Pepsin appeared to have a slight effect on bone corrosion at either pH.

Proteolytic activity was slightly greater in solutions at pH 1.66 than in solutions at pH 2.35 (table 2). Four hours of incubation and the presence of bones in solution each appeared to decrease the proteolytic activity of the solutions.

The results of these studies support the hypothesis that the lower pH of gastric juice is principally responsible for greater bone corrosion in falconiform stomachs than in strigiform stomachs (Duke et al. 1975). The proteolytic activity of the simulated gastric juice solution apparently was also slightly involved in bone corrosion.

Literature Cited

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TABLE 1
Effect of pH or pepsin on digestion of bone.

Contents/100 ml Bone Group	Pepsin (mg)	pH	Bone loss (%)*
A	0	1.66	70.7 ± 10.7 (5)
A	"	2.35	25.2 ± 14.7 (5)
B	"	1.66	64.8 ± 14.8 (5)
B	"	2.35	24.5 ± 8.7 (5)
A	200	1.66	81.9 ± 10.7 (5)
A	""	2.35	32.6 ± 18.3 (5)
B	""	1.66	75.6 ± 10.1 (5)
B	""	2.35	34.0 ± 11.0 (5)
A	400	1.66	81.8 ± 10.5 (6)
A	"	2.35	37.0 ± 19.8 (6)
B	"	1.66	80.8 ± 11.4 (6)
B	"	2.35	32.9 ± 14.1 (6)

* Mean ± S. D. with number of experiments in parentheses.

TABLE 2
Effects of incubation and/or digestion on
Proteolytic activity of simulated raptor gastric juice
solutions containing 4 mg/ml of pepsin.

Treatment	mg/ml of tyrosine released* pH 1.66	pH 2.35
not incubated; no bones added	4.13 (2)**	4.43 (2)
4 hr. of incubation; no bones added	3.21 (2)	2.67 (2)
4 hr. of incubation; bones added	2.73 (2)	1.96 (2)

* see text.
** mean with number of samples tested in parentheses.