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TECHNICAL REPORT
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ATLAS OF GOAT ANATOMY.
PART I: OSTEEOLOGY

by
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September 1970

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ATLAS OF GOAT ANATOMY. PART I: OSTEOLOGY

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Project 1T062110A027
FOREWORD

The work described in this report was authorized under Project 1T062110A027, Wound Ballistics (U). This work was started in September 1968 and completed in March 1970.

In conducting the research described in this report, the investigators adhered to the "Guide for Laboratory Animal Facilities and Care," as promulgated by the Committee on the Guide for Laboratory Animal Resources, National Academy of Sciences—National Research Council.

Acknowledgments

The authors wish to acknowledge the technical assistance of William J. Kelly, John J. Holter, Bernard Meyers, Joseph B. Scott, and Garnet E. Affleck, Jr., in performing the photographic procedures.
DIGEST

The purpose of this investigation was to establish a reference source for the anatomy of the angora goat (*Capra hircus*). This report, the first in a series, presents the skeletal anatomy of this animal.
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<thead>
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<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
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<td>Right Humerus, Medial and Caudal Aspects</td>
<td>35</td>
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<tr>
<td>29</td>
<td>Left Pectoral Foot, Cranial Aspect</td>
<td>36</td>
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<td>30</td>
<td>Left Pectoral Foot, Caudal Aspect</td>
<td>37</td>
</tr>
<tr>
<td>31</td>
<td>Left Pectoral Foot, Lateral Aspect</td>
<td>38</td>
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<tr>
<td>32</td>
<td>Left Pectoral Foot, Medial Aspect</td>
<td>39</td>
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<td>Lumbar Vertebrae, Dorsal Aspect</td>
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<td>34</td>
<td>Lumbar Vertebrae, Ventral Aspect</td>
<td>41</td>
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<tr>
<td>35</td>
<td>Sixth Lumbar Vertebra, Ventral and Cranial Aspects</td>
<td>42</td>
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<tr>
<td>36</td>
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<td>43</td>
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<tr>
<td>37</td>
<td>Pelvis With Sacral and Caudal Vertebrae Attached, Left Lateral Aspect</td>
<td>44</td>
</tr>
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<td>38</td>
<td>Pelvis With Sacral and Caudal Vertebrae Attached, Ventral Aspect</td>
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</tr>
<tr>
<td>39</td>
<td>Left Femur, Cranial and Lateral Aspects</td>
<td>46</td>
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<td>Left Femur, Caudal and Medial Aspects</td>
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<td>41</td>
<td>Left Tibia, Cranial and Caudal Aspects</td>
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<tr>
<td>42</td>
<td>Left Tibia, Lateral and Medial Aspects</td>
<td>49</td>
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<tr>
<td>43</td>
<td>Left Pelvic Foot, Cranial Aspect</td>
<td>50</td>
</tr>
<tr>
<td>44</td>
<td>Left Pelvic Foot, Caudal Aspect</td>
<td>51</td>
</tr>
<tr>
<td>45</td>
<td>Left Pelvic Foot, Lateral Aspect</td>
<td>52</td>
</tr>
<tr>
<td>46</td>
<td>Left Pelvic Foot, Medial Aspect</td>
<td>53</td>
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I. INTRODUCTION.

The angora goat (Capra hircus) has been the main experimental animal used by the Biophysics Laboratory, Edgewood Arsenal, Maryland, for many years. Knowledge of goat anatomy is important during both the planning and experimental stages of projects. Because no readily usable information on goat anatomy is available, this report has been written to provide a reference source for this information. This report, the first in a series, presents the skeletal anatomy of the angora goat. Part II: Serial Cross Sections, which is near completion, presents serial 1-inch cross sections of the entire goat.

II. MATERIALS AND METHODS.

The goats used in the Biophysics Laboratory are all castrated males, are generally over 3 years old, and weigh from 30 to 50 kg. The divisions and average number of the bones of the goat are shown in the table. The intact skeleton (figure 1) was prepared in the fall of 1954 from one goat that weighed approximately 50 kg. The individual bones (figures 2 through 46) were selected from over 2000 autopsies and are typical of the average angora goat.

Beginning in 1968, these bones (already prepared by the methods described in the appendix) were photographed, drawn, and labeled. The first Nomina Anatomica Veterinaria (NAV)* was published in October 1968, too late to be used for planning this report. The authors have reviewed all figures, however, and attempted to bring them into agreement with the NAV. Future sections of this atlas will be in the correct Latin nomenclature in agreement with the NAV.

<table>
<thead>
<tr>
<th>Division</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial skeleton:</td>
<td></td>
</tr>
<tr>
<td>Vertebral column*</td>
<td>42</td>
</tr>
<tr>
<td>Skull and hyoids</td>
<td>35</td>
</tr>
<tr>
<td>Ribs and sternum</td>
<td>27</td>
</tr>
<tr>
<td>Appendicular skeleton:</td>
<td></td>
</tr>
<tr>
<td>Pectoral limbs</td>
<td>26</td>
</tr>
<tr>
<td>Pelvic limbs</td>
<td>37</td>
</tr>
<tr>
<td>Total</td>
<td>167</td>
</tr>
</tbody>
</table>

*The vertebral formula is C7T14L4S4Cy10 to Cy12. Variation is common except in the cervical region (T12 to T14, L5 to L6).

The permanent dental formula is 2(0 0 4 C 0 0 P 0 3 M 3). 32.

III. SKELETAL ANATOMY.
Figure 8. Right Mandible, Lateral Aspect
Figure 9. Right Mandible, Medial Aspect
Figure 10. Bones of the Middle Ear (11 X)

HAMMER

HEAD

HANDLE

NECK

ANVIL

LONGBRANCH

BODY

SHORT BRANCH

STIRRUP

HEAD

BASE

LEG
Figure 12. Third Cervical, Axis, and Atlas Vertebrae, Dorsal Aspect.
Figure 15. Axis Vertebra, Caudal Aspect
Figure 16. Third Cervical Vertebra, Right Lateral Aspect
Figure 17. Ribs and Sternum, Right Lateral Aspect
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Figure 40. Left Femur, Caudal and Medial Aspects
Figure 42. Left Tibia, Lateral and Medial Aspects

MEDIAL ASPECT

TIBIAL TUBEROSITY

CRET

BODY

LATERAL ASPECT

LATERAL MALLEOLUS

LATERAL MALLEOLUS

CRET

BODY
Figure 43. Left Pelvic Foot, Cranial Aspect
Figure 44. Left Pelvic Foot, Caudal Aspect
Figure 46. Left Pelvic Foot, Medial Aspect
SELECTED REFERENCES


APPENDIX

PREPARATION OF OSTEOLOGICAL SPECIMENS

By Clarence E. Hopkins, Sr.

This process is patterned after that used by Dr. M. L. Washburn, who introduced it to this laboratory. Dr. Washburn organized the osteology section of the Biophysics Laboratory in 1954 to provide autopsy support for projects involving the skeletal system.

The essential steps in this process are digestion of soft tissues with alkali and bleaching.

I. MATERIALS AND METHODS.

A. Equipment.

1. A large steel tank. For a moderate amount of work with an animal the size of a goat, a 50-gal steel drum is convenient.

2. Hot plate.

3. Wire baskets made with hardware cloth fine enough to prevent passage of small bones.

4. Thermometer 0° to 100°C.

5. Adjustable thermoswitch 100° to 400°F range, 20 amp at 115 volts.

6. Indicator light 110 volts.

7. Miscellaneous standard electrical connections.

B. Reagents.

1. Sodium hydroxide pellets.

2. Hydrogen peroxide.

C. Method.

1. Digestion.

Mount the tank so that the hot plate contacts the bottom but does not support weight. Connect the thermoswitch in series with the hot plate and indicator light; and insert the thermoswitch in the tank near the bottom. Lower the thermometer into the solution with a wire.
Fill the tank with a 1% sodium hydroxide solution and cover. Plug the hot plate and
indicator light into the thermostat and adjust it to maintain the digesting solution at 45°C as
indicated by the thermometer.

Deflesh all bones as much as possible with a knife or scalper blade. Then place them
in labeled wire baskets and immerse in the heated solution. Watch the bones closely, and every 2
to 3 hours remove them from the solution, rinse with tap water and gently clean with a small
brush.

a. Time.

The time required varies, and bones that are left in the solution too long will scale and
crack when dry. Table A gives the approximate times required but should be used only as a
guide. The time actually required for best results with any given specimen must be determined
by repeated observation.

b. Temperature.

The temperature of the alkali bath is quite important. A specimen that would require
treatment for several weeks in a cold 1% sodium hydroxide solution can be processed
completely in 1 or 2 days in a warm solution of the same strength. Even a moderate elevation of
temperature (5° or 10°C) above room temperature causes marked acceleration of the process. A
very high temperature, however, is detrimental because the bones are softened before the soft
tissues have been digested sufficiently. For efficient work and successful results, a temperature
between 45° and 48°C has proved to be very satisfactory.

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Table A. Times Required for Digestion

<table>
<thead>
<tr>
<th>Bone</th>
<th>Time (hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>apula</td>
<td>16</td>
</tr>
<tr>
<td>pe-erus</td>
<td>16-20</td>
</tr>
<tr>
<td>t-o-ultr.</td>
<td>16-20</td>
</tr>
<tr>
<td>i</td>
<td>18-24</td>
</tr>
<tr>
<td>sc vertebra</td>
<td>24-30</td>
</tr>
<tr>
<td>sc vertebra</td>
<td>2-36</td>
</tr>
<tr>
<td>umbar vertebra</td>
<td>24-30</td>
</tr>
<tr>
<td>lysis</td>
<td>24-30</td>
</tr>
<tr>
<td>armula</td>
<td>36-40</td>
</tr>
<tr>
<td>femur</td>
<td>30-36</td>
</tr>
<tr>
<td>TP</td>
<td>24-30</td>
</tr>
<tr>
<td>t</td>
<td>36-48</td>
</tr>
<tr>
<td>tibia</td>
<td>36-48</td>
</tr>
<tr>
<td>tibia</td>
<td>36-48</td>
</tr>
<tr>
<td>cruller</td>
<td>36-48</td>
</tr>
<tr>
<td>ph... (uncleaned)</td>
<td>48/72</td>
</tr>
</tbody>
</table>

Appendix 58
c. Solution.

Other factors being equal, the time required for soft-tissue removal decreases as the concentration of the alkali is increased. A 1% solution of sodium hydroxide was found to be satisfactory.

d. Quantity of Soft Tissue.

The bones should be cleaned fairly well of soft tissue before digestion if that is possible without the risk of losing small bones, and they should be processed when fresh. In general, the softer the tissue, the faster the processing. Specimens that have been removed from the animal for a long time with dry hard tissues adhering to the bones or embalmed specimens require a longer period of processing than do fresh ones.

2. Bleaching.

A solution of hydrogen peroxide serves admirably as a bleach for bones. It has no noticeable decorative effect upon the bones and gives them a nice snow-white appearance. A solution of sodium hypochloride was tried as a substitute for hydrogen peroxide because it is much more economical, but the results were disappointing. The bones had a faint yellowish tinge, and they flaked excessively.

A 28% or 30% solution of hydrogen peroxide also may be used for bleaching with very good results, but a 3% solution conserves material and gives equally good results. The procedure for bleaching is as follows.

a. Transfer the bones from the wire basket to a suitable container.

b. Cover the bones with a 3% solution of hydrogen peroxide, and place a lid on the container. (The identification number of the bone should be marked on the container.)

c. Allow the bones to bleach until white; 4 to 8 hours should be sufficient for bleaching.

d. Remove the bones from the bleach, rinse them in water, and transfer them to a table to dry. Paper towels under the specimens aid drying.

3. Labeling.

Each individual bone should be labeled for identification as soon as it is bleached and dried. An India-ink label is more durable than a pencil label.
**ATLAS OF GOAT ANATOMY, PART I: OSTEOLOGY**

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14. KEYWORDS

Angora goat  
*Capra hircus*  
Skeletal anatomy  
Bone digestion  
Osteology