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CONTENTS

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THE AMBULATORY MUSCULATURE OF THE CRAYFISH CAMBARUS BARTONII SCIOTENSIS

(*Rhoades,* 1944)

BY

D. HUGH PUCKETT
L. L. FARMER
L. R. EMMONS

ACKNOWLEDGEMENTS

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INTRODUCTION

The present study of the ambulatory musculature of *Cambarus bartonii sciotensis* (Rhoades, 1944) was undertaken in order to determine to what extent the musculature of a crayfish belonging to the subfamily Cambarinae resembles that of a member of the Astacinae. The work of Schmidt, 1915, on the musculature *Astacus astacus* (=*A. fluvistilis;* see Bott 1950) provides an excellent foundation for such a comparative study. In many instances the descriptions of the muscles given by Schmidt adequately serve for those of *Cambarus bartonii sciotensis,* but there are a number of significant differences that seem to justify this report.

Because the musculature of the second pereiopods seem to be more generalized than that of the other ambulatory appendages, it is described in detail and those of the other legs are compared with it.

SKELETON

The skeleton of the crayfish *Cambarus longulus longulus* (Girard 1852) has been described and illustrated by Snodgrass (1952) and this description applies equally well to the skeleton of *Cambarus bartonii sciotensis.* The essential features of the skeleton necessary to an understanding of the ambulatory musculature include only the pleural, sternal, and endophragmal skeleton associated with segments VIII-XII. The pleural skeleton consists of a series of irregular, fused cuticular plates marked by thickened ridges along the intersegmental sutures and from which project mesially the Y-shaped pleural apodemes. The sternal elements consist of a series of fused median plates (the plate of the 12th segment is free in the male) that bear lateral extensions (pleurosternal brachia) between all of the appendages except the fourth and fifth pereiopods. The arms of the pleural apodemes project in such manner that the anterior arm articulates with the posterior portion of the paraphragm of the sternal apodeme immediately anterior to it and the posterior arm articulates with the anterior portion of the paraphragm of the sternal apodeme immediately posterior to it. The only departure from the description presented by Snodgrass (1952), is the numbering of the cheliped as the first leg as opposed to designating the second pereiopod as the first leg.

DESCRIPTION OF THE AMBULATORY MUSCULATURE

Second Leg

1. *Musculus remotor posterior* (*M. remotor* Schmidt, in part) (Figs. I, III, IV, VI, VIII—MRP). Arises by three heads: (a) the shortest, on the anterolateral portion of the fourth pleural apodeme and the pleural brachium immediately anterior to the base of the apodeme; (b) the longest, on the pleural arch immediately dorsal to the base of the fourth pleural apodeme; and (c) the mesial, broadest head, from the posterior face of the third pleural apodeme. These heads converge to be inserted on the coxal phragma (Figs. II, VIII—CP) on the posterolateral proximal margin of the coxa.

2. *Musculus remotor anterior* (*M. remotor* Schmidt, in part) (Figs. II—MRA). A ribbon-like muscle that takes its origin on the posterior side of the base of the third pleural apodeme and extends posterolaterally and ventrally to be inserted on the coxal phragma immediately anterolateral to the insertion of *M. remotor posterior.*

3. *Musculus depressor basipoditis posterior* (*M. depressor* Schmidt, in part) (Figs. I, II, III, IV, VI—MDPB). This is the most complex muscle of

the leg, taking its origin in six heads: (a) a short mesial head on the caudomesial and mesial surface of the coxa; (b) a short lateral head on the caudolateral proximal rim of the coxa; (c) the broadest head on the anteroventral face of the sternopleural brachium between the second and third legs; (d) a dorsolateral head on the pleuron under cover of the longest head of *M. remotor posterior;* (e) a dorsemesial head on the posterior surface of the posterior arm of the third pleural apodeme and (f) a short lateral head on the posterior proximal rim of the coxa. Fibers from the first five heads join a long tendon that is inserted on the phragma on the mesial rim of the basipodite. Some of the fibers of the first head and all of the fibers of the sixth head extend to the rim of the basipodite around the base of the tendon and posterolateral to it as far as the posterior condyle (Figs. I, II–PC).

4. *Musculus depressor basipoditis anterior* (*M. depressor* Schmidt, in part) (Figs. II, V–MDBA). This ribbon-like muscle arises on the sternum immediately posterior to the sternopleural brachium between the second and third legs. It is inserted on the anteromesial proximal rim of the basipodite immediately anterior to the phragma.

5. *Musculus levator basipoditis lateralis* (*M. levator* Schmidt, in part) Figs. I, II, III, IV, V–MLBL). This muscle takes its broad origin on the lateral and posterolateral wall of the coxa, and is inserted by a broad short tendon on the anterolateral proximal rim of the basipodite.

6. *Musculus levator basipoditis medialis* (*M. levator* Schmidt, in part) (Figs. I, II, IV, V. VI–MLBM). This muscle arises by two heads; (a) the larger on the posterior surface of the third pleural apodeme under cover of the fifth head of *M. depressor basipoditis posterior;* and (b) the smaller, ribbon-like head on the sternum immediately dorsal to the head of *M. depressor basipoditis anterior*. The fibers of both heads coverge to be inserted by a broad, short tendon immediately lateral to the anterior condyle of the basipodite.

7. *Musculus promotor* (Schmidt) (Figs. II, V. VI, VII–MP). This muscle arises by three heads; (a) the posterior head on the anterior surface of the posterior arm of the third pleural apodeme; (b) the lateral head on the pleuron immediately dorsal to the base of the third pleural apodeme; and (c) the anterior head (Fig. VIII–MP-C) on the posterior face of the anterior arm of the third pleural apodeme. The fibers of the three heads join to be broadly inserted on the anterioproximal rim of the coxa.

Musculus reductor ischiopoditis (Schmidt) Figs. VI, VII–MRI). This is the only muscle of the leg that lacks one opposing its action. It takes its origin on the upper anterior surface of the basipodite and is broadly inserted on the proximal posterior rim of the ischiopodite.

The anatomy and function of the musculature of the segments of the ambulatory appendages distal to the basipodite have been accurately described for the crayfish *Astacus astacus* (= *A. fluviatilis*) by Schmidt, 1915. These descriptions adequately apply to those of Cambarus *bartonii sciotensis,* and the reader is referred to this work for a discussion of the anatomy and function of these muscles. The muscles as named by Schmidt for each of these segments are indicated in the legend.

COMPARISON OF THE MUSCULATURE OF THE OTHER AMBULATORY APPENDAGES WITH THAT OF THE SECOND LEG

Leg I (cheliped).—The musculature of the cheliped is similar to that described for the second leg except that *M. remotor anterior* is lacking and the muscles of the cheliped are larger than those of the second leg.

Leg III.—The musculature of the third leg is in every way similar to that described for the second leg.

Leg IV.—*M. remotor anterior* is lacking in the fourth leg. The broadest head of *M. depressor basipoditis posterior* (Fig. III—MDBP-C) originates broadly on the sternum immediately dorsal to the origins of *M. depressor basipoditis anterior* (Fig. IV—MDBA) and the ribbon-like head of *M. levator basipoditis medialis* (Fig. IV—MLBM-B. *M. basipoditis depressor posterior* lacks the dorsolateral head from the pleuron and the dorsomesial head from the corresponding pleural apodeme. All other muscles of the fourth leg are similar to those of the second leg.

Leg V.—*M. remotor medialis* (Fig. V—MRM), originates on the anterior surface of the pleurosternal brachium posterior to the fifth leg immediately posterior to its junction with the posterior margin of the eighth sternal apodeme and passes ventrolaterally to be inserted lateromesially on the proximal posterior margin of the coxa. This muscle appears to be the homolog of the mesial head of *M. remotor posterior* (Figs. I, III, VIII—MRP-A) as described for the four anterior legs although it appears as a separate muscle in the fifth leg. *M. remotor anterior* is not present in the fifth leg. All other muscles of the fifth leg are similar to the muscles of the second leg. *M. depressor basipoditis posterior* is less complex in the fifth than in the second leg, lacking the following heads: (1) the dorsolateral head from the pleuron (Fig. II—MDBP-D); (2) the dorsomesial head from the posterior surface of the posterior arm of the pleural apodeme (Fig. II—MDBP-C); and (3) the short lateral head from the caudolateral proximal rim of the coxa (Fig. II—MDBP-B).

COMPARISON OF THE AMBULATORY MUSCULATURE OF *CAMBARUS BARTONII SCIOTENSIS* WITH THAT OF *ASTACUS ASTACUS*

The important differences in the musculature of the two species of crayfish are outlined in the following discussion. These differences are based on the findings of the present work compared with the findings reported by Schmidt for *Astacus* and on dissection of *Pacifastacus gambelii connectens* (Faxon, 1914), a member of the subfamily *Astacinae*.

Schmidt reports a single head for *M. promotor* in *Astacus* whereas there are three heads of the promotor muscle in *Cambarus*. Schmidt refers to "fibers" of this muscle originating on the "rostral" and "caudal" endosternites as well as on the base of the epimeral plate. Dissection of *Pacifastacus* indicates that these portions of the muscle originating from three points correspond to the three heads of the muscle in *Cambarus*.

M. remotor as recognized by Schmidt actually consists of two distinct muscles having separate origins and insertions in *Cambarus and Pacifastacus*. These muscles are *M. remotor posterior* and *M. remotor anterior* (Figs. I, III) of the first four legs and *M. remotor posterior* and *M. remotor medialis* (Fig. V) of the fifth leg.

Schmidt reports only one levator muscle in *Astacus*, however, two are present in *Cambarus* and *Pacifastacus*. He descrcibes a "main branch" which corresponds with the lateral head of *M. levator medialis* of *Cambarus* and *Pacifastacus*, and a "median branch" which he reported originates "rostromedially at the proximal edge of the coxopodite". This "median branch" corresponds to the mesial head of *M. levator basipoditis medialis* of *Cambarus* and *Pacifastacus* in which it originates not in the coxa but on the ventral thoracic sternum. Schmidt also refers to a lateral head of *M. levator* but it was found to be a separate levator muscle in both species studied and has been designated here as *M. levator basipoditis lateralis*.

The two depressor muscles of the coxa are recognized by Schmidt as a single muscle consisting of a "main branch" and a "lateral branch". The main branch was described as having two parts: (1) an anterior median one which corresponds to heads MDBP-C and MDBP-E or *M. depressor basipoditis posterior* (Figs. I, II) of *Cambarus*, these two heads are not distinct in *Pacifastacus*, and (2) a lateral posterior part which corresponds to head MDBP-D of *M. depressor basipoditis posterior* of *Cambarus* (Figs. I, II). The smaller lateral branch described by Schmidt corresponds to head MDBP-B and MDBP-F of *M. depressor basipoditis posterior* of *Cambarus* (Figs. I, III). These two heads are not distinctly separated in *Pacifastacus*. Schmidt failed to describe that part of *M. depressor* which corresponds to head MDBA-A of *M. depressor basipoditis posterior* although dissection showed such fibers to be present in *Pacifastacus* as well as in *Cambarus*. *M. depressor basipoditis anterior* was not described by Schmidt as being present in *Astacus*. A small group of fibers probably corresponding to this muscle are present in *Pacifastacus*.

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EXPLANATION OF FIGURES

Abbreviations Used

AC — Arthrocorium
BP — Basipodite
CP — Coxal phragma
CXP — Coxopodite
MABC — *M. Abductor carpopoditis*
MABD — *M. Abductor dactylopoditis*
MADC — *M. Abductor carpopoditis*
MADD — *M. Abductor dactylopoditis*
MDBA — *M. depressor basipoditis anterior*
MDBP-A — *M. depressor basipoditis posterior,* head a
MDBP-B — *M. depressor basipoditis posterior,* head b

MDBP-C	– *M. depressor basipoditis posterior,* head c
MDBP-D	– *M. depressor basipoditis posterior,* head d
MDBP-E	– *M. depressor basipoditis posterior, head e*
MDBP-F	– *M. depressor basipoditis posterior, head f*
MLBL	– *M. levator basipoditis lateralis*
MLBM-A	– *M. levator basipoditis medialis,* head a
MLBM-B	– *M. levator basipoditis medialis,* head b
MP-A	– *M. promotor,* head a
MP-B	– *M. promotor,* head b
MP-C	– *M. promotor,* head c
MPP	– *M. productor propoditis*
MRA	– *M. remotor anterior*
MRI	– *M. reductor ischiopoditis*
MRM	– *M. remotor medialis*
MRM-A	– *M. reductor meropoditis,* head a
MRM-B	– *M. reductor meropoditis,* head b
MRP	– *M. reductor propoditis*
MRP-A	– *M. remotor posterior,* head a
MRP-B	– *M. remotor posterior, head b*
MRP-C	– *M. remotor posterior,* head c
STPB	– sterno-pleural brachium
1-PLAP	– First pleural apodeme
1-SAP	– First sternal apodeme
3-MAX	– Third maxilliped
5-PLAP	– Fifth pleural apodeme
8-SAP	– Eighth sternal apodeme

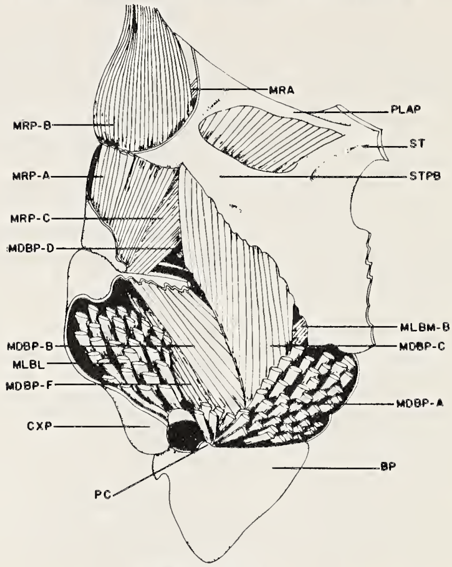

FIGURE I.

Posterion view of Leg II with posterior face of coxal exoskeleton and the arthrocorium of the sterno-coxal articulation removed.

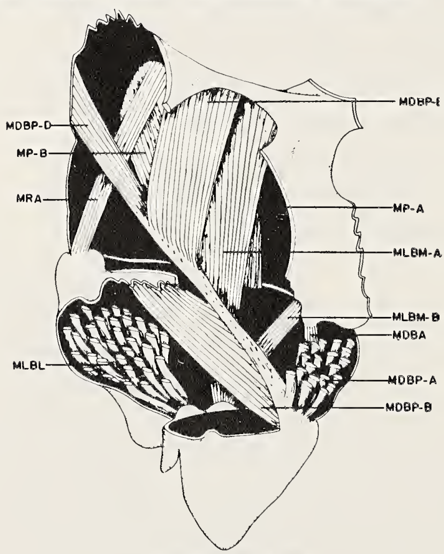

FIGURE II.

Same as Fig. I with *M. remotor posterior,* and heads c, f and some fibers of head a of *M. depressor basipoditis posterior* removed.

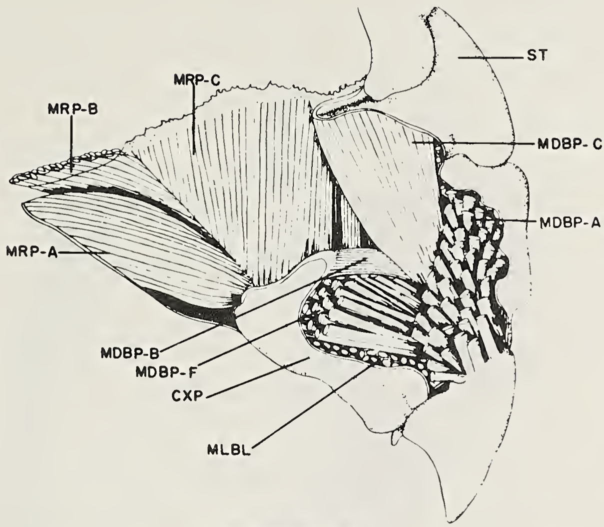

FIGURE III.
Posterior view of leg IV dissected in a manner similar to that shown in figs. I and II for Leg II. Leg four lacks the sterno-pleural brachium.

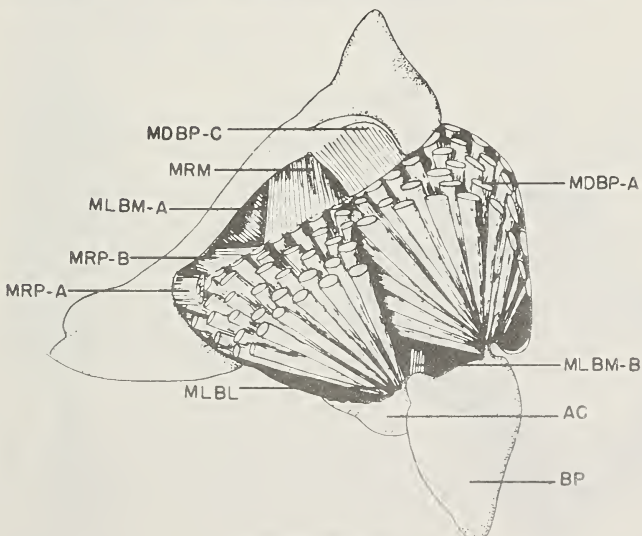

FIGURE IV.
Posterior view of leg V with posterior face of the coxal exoskeleton and the arthrocorium of the sterno-coxal articulation removed.

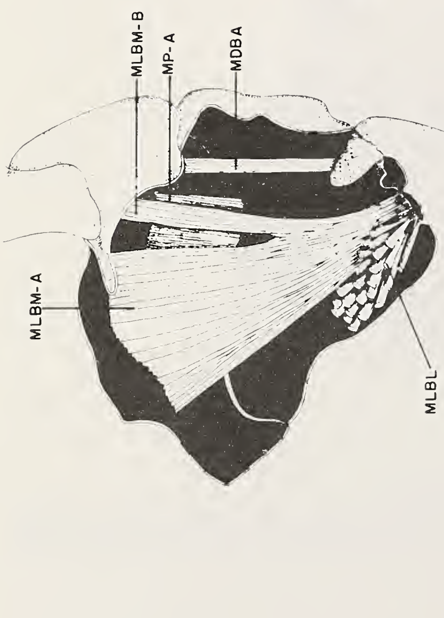

FIGURE V.

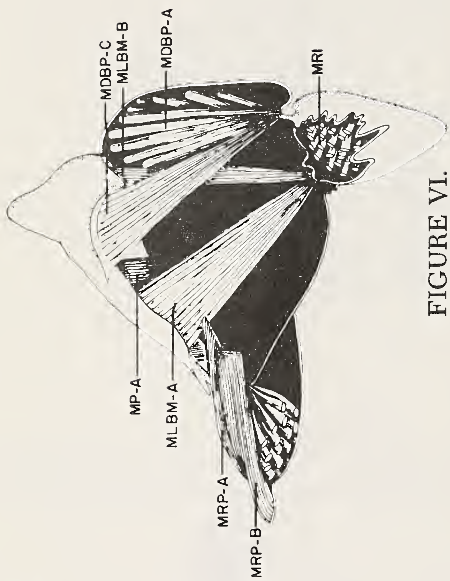

FIGURE VI.

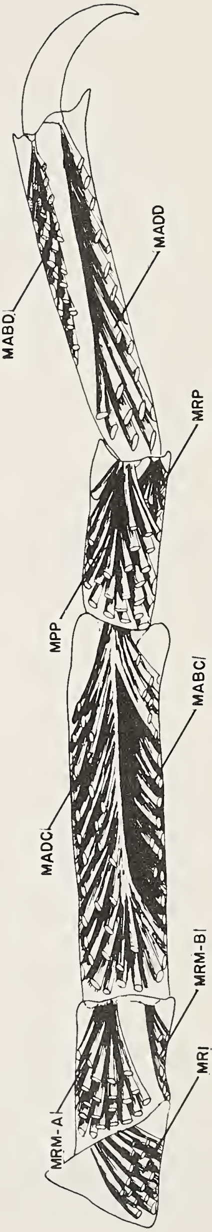

FIGURE VII.

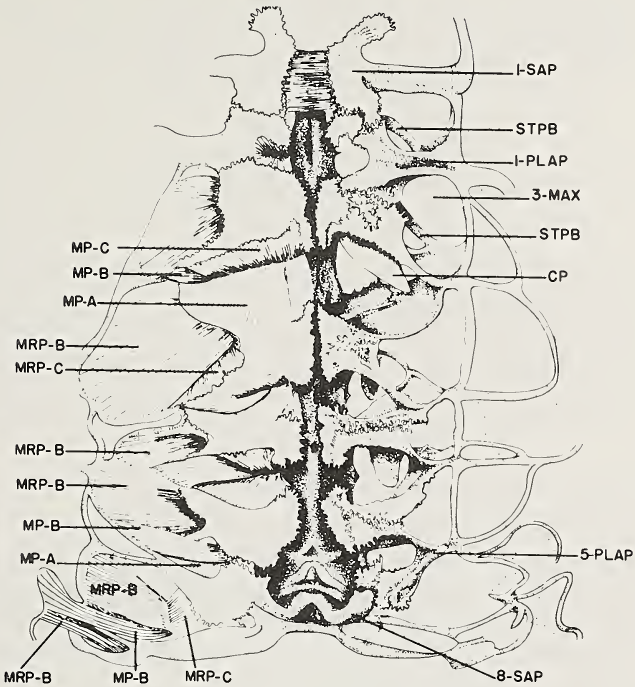

FIGURE VIII.
Dorsal view of the pleural and sternal skeleton with muscles inserted on the left.

FIGURE V.
Same as figure III with some fibers of *M. levator basipoditis lateralis,* and all of *M. levator basipoditis posterior* and *M. remotor posterior* removed.

FIGURE VI.
Same as Fig. IV with *M. levator basipoditis lateralis, M. remotor medialis,* and the more posterior fibers of *M. depressor basipoditis posterior* removed.

FIGURE VII.
The musculature of the segments of the fourth leg distal to the coxopodite.

THE BLOOD PICTURE OF WOOLLED SHEEP AND DAIRY GOATS

LUBOW A. MARGOLENA*
Agricultural Research Service
United States Department of Agriculture
Beltsville, Maryland

According to Holman (8), blood ranges and not averages are important in clinical and experimental work. His remark, " . . . that is where veterinary literature gives one so little help," is almost as applicable today as it was when originally written 12 years ago. The voluminous data presented in the AF Technical Report of 1951 (1) does include blood ranges but little is mentioned as to breed, sex, age and environment of the animals in question.

The present studies, carried out with two breeds of woolled sheep and one variety of dairy goat, were undertaken for the following reasons:

1. To find out whether seasonal changes in the skin and follicles observed in some of these animals, bear a direct relationship to their hematological picture. Seasonal differences were found to exist in the skin of Merino and Hampshire sheep, in as much as mitotic rates in their growing hair follicles were 60 to 70 per cent higher in summer than in winter (12). Toggenburg goats undergo a regular shedding in early summer.

2. To verify the assumption that certain blood figures tend to be characteristic for a given breed, age and sex.

3. To contribute data for possible diagnostic purposes.

MATERIAL

Two groups of animals, kept under identical conditions except for their dietary regimes, were used (Table 1).

The animals of the seasonal group were kept on pasture and the diet of the sheep and goats of the standard group consisted of 3-1/2 pounds alfalfa hay to 1/2 to 3/4 pounds alfalfa meal a day. All the animals could find protection in similar adjacent pens on the grounds of the Agricultural

* It is with pleasure and gratitude that I acknowledge here the unfailing cooperation of G. E. Whitmore, Veterinarian, Animal Husbandry Research Division; the special role of Dr. J. H. Turner, Animal Disease and Parasite Research Division, and the attentive execution of figures by R. J. Schied, our histopathologist, of the United States Department of Agriculture.

TABLE 1

Seasonal Group	Standard Group
Merino ewe No. 13	Merino ewe No. 33
Merino ram No. 16	Merino ram No. 3
Merino ram lamb No. 167	Merino ewe lamb No. 200
Hampshire ewe No. 48	Hampshire ewe No. 36
Hampshire ram No. 49	Hampshire ram No. 20
Toggenburg doe No. 54	Toggenburg doe No. 25
Toggenburg doe No. 60	Toggenburg doe No. 42
Toggenburg buck No. 23	

Research Center at Beltsville, Maryland, where water was always available.

The experimental sheep and goats served primarily as a source of observations on the biology of skin, wool and hair follicles. They were all born between February and March, 1953, and thus were practically of the same age. Ram lamb No. 167 was born to Merino ewe No. 13 on January 13, 1955; and ewe lamb No. 200 to Merino doe No. 33 on March 23, 1955.

Because both pregnancy and lactation may affect the ewe's blood picture (2, 11) and that to an extent determined by variety and breed (13) the peculiarity of the unpredicted divided nursing, as practiced in both groups, will be noted here. Thus, in addition to its mother's milk, each lamb was also nursed by a goat, namely doe number 54 of the seasonal group and doe number 25 of the standard group.

To the best of our knowledge, neither of the does was bred, or pregnant during the period of observation, but started lactating after being coaxed into it by a demanding lamb. Virgin lactation has been reported by owners of dairy goat flocks too often to doubt the possibility of the phenomenon.

Body weight and fleece weight. With the exception of one ewe (No. 13) and one ram (No. 16), all the animals gained weight during the experimental period. One ram (No. 16) died before the completion of the observations on October 7, 1955 for no ascertainable reason.

The ratio between fleece weight and body weight was about twice as great in the Merino as compared to the Hampshire in the seasonal group, and more than twice in the control group.

Phenothiazine treatment. All the animals were treated with phenothiazine on June 15 and September 14, 1955.

METHODOLOGY

With the exception of the summer months, when sampling was more frequent, circulating blood, obtained from the jugular vein, was collected every two months, resulting in all in eight samples per year. The animals were attracted by the sound of the caretaker's bucket, regularly between 8:30 and 9:30 A.M. and bled in the pens to avoid unnecessary variations in their blood picture. About 10 ml were drawn into citrated tubes, after which a drop of fresh blood was spread immediately on each of the few slides prepared for the differential counts. The smears were stained with Giemsa's solution and kept protected until needed for study. Three hundred leucocytes were observed per sample.

Determinations from citrated blood were made as soon as feasible after procurement and started in the order given: sedimentation rate, cell volume, total leucocyte count, hemoglobin percentage. Erythrocytes were also enumerated using Gower's solution as a diluent, but because of inconsistency in results and lack of time to repeat, will not be mentioned further.

Sedimentation rates were observed in Winthrobe tubes, steadied perpendicularly and read 24 hours later. Compared to laboratory temperatures recommended for human blood (22 to 27°C) (3,9) our Beltsville July and August temperatures reaching to 36 and 38° C, appear rather high. However, the blood of sheep and goats tested did not seem to be affected by it. Incidentally, the normal body temperature of sheep and goats is higher than in humans and this may perhaps explain greater tolerance for warmer weather. For example, figures for the experimental animals on control diet during July varied from 101.6 to 104.4°F.

Volume of packed erythrocytes was evaluated in Wintrobe hematocrit tubes filled exactly to the mark 10, and centrifuged at 3000 r.p.m. for 30 minutes.

Leucocyte counts were made in the usual manner and from figures obtained from 1 to 20 dilutions in 4 per cent acetic acid.

Hemoglobin percentage was figured out by the acid haematin and read in the Evelyn Colorimeter.

Parasitological observations. Due to the interest and active cooperation of Dr. James H. Turner, the sheep and goats were also tested for parasites on the same or following day the blood samples were taken, beginning, however, a few months later than the start of other tests.

Fecal samples were examined for ova of: *Cooperia curticei, Haemonchus contortus, Nematodirus spathiqer, Oesophagostomum sp., Ostertagia circumcincta, Skrjabinema ovis, Strongyloides, Trichostongylus sp.,* and *Trichurus ovis.* Of these parasites *Haemonchus* is of primary importance to this study, because when present in high numbers it causes anemia in the host, whereas, the others may contribute to the loss of weight.

RESULTS

Hemoglobin values (figures 1, 2, 7 and 8), found in Beltsville sheep fall, more or less, within the range reported by other workers. While the Merino rams showed higher values than the ewes, it must be remembered that the blood picture of the ewes may have been influenced by pregnancy and lactation. No such differences favoring the males were encountered in the Hampshire animals. Incidentally, it may also be worth nothing that lactation did not seem to affect the haemoglobin values of the does. Age differences with lower values in young animals were recorded in both ewe and ram lambs as compared with their mothers.

Moderate infestations of *Haemonchus,* as reflected in the egg counts, were observed in the seasonal animals only in three instances during the course of the study: in March, April and September, in doe No. 54, ewe No. 13, and ram 49, respectively. A summer dip in hemoglobin values in pasture-fed animals could be related to parasite infestation, and examinations carried out still more frequently would perhaps give a more accurate blood picture.

The egg counts revealed slightly higher infestations of *Trichostrongulus* and *Oesophagostomum* in the animals on standard diet, but *Haemochus* appeared in approximately the same numbers as in animals on the seasonal diet. Moderate infections of *Haemonchus* were observed in March, June and September, and animals showing the highest egg counts of this species were: does No. 25, and No. 42; doe No. 25 and ewe No. 33; and again does No. 25 and 42. Doe No. 42 also showed a low hemoglobin and hematocrit average.

Erythrocyte volume (figures 3, 4, 7 and 8 for packed cell values). As with hemoglobin, the red cell volume tended to be lower in the lambs than in sexually mature animals. Within its range, the general conditions of the animal probably more than sex, influences the volume. One ewe, No. 13, which was not a particularly thrifty animal, failed to gain weight in the course of the experimental period, and that, rather than its sex is thought to be responsible for the lower cell volume, as compared to other Merino sheep. Pregnancy and lactation could be held only partly responsible in as much as the pregnant and also lactating Merino No. 33 showed a cell volume pretty close to that of the ram in the same standard group, Merino No. 3.

While all the sheep showed supposedly normal hematologic figures, Hampshire ewe No. 36 stands out as an animal with unusually high values. This ewe was an altogether thrifty, big and domineering animal, but she happened to produce less wool than the other Hampshires. The average ranges of Hampshire animals No. 48, 49, and 20 are comparable to those found by others, including Todd (15), as recorded for 35 pregnant Hampshire ewes.

Sedimentation rates are generally expected to be higher in the female of the species than in the male. From data presented in figures 5 and 6, one may perhaps note a slight trend in that direction in the Merino, but hardly in the Hampshires. Both Merino ewes delivered lambs and nursed them during part of the observation period, which may have slightly influenced their sedimentation rates. However, Hampshire ewe No. 36 aborted a few days before the tests were made in February 1955, and that had no apparent effect on the sedimentation rate, hemoglobin or cell volume values of this hardy ewe.

Both the ewe and ram lambs (Merino) had at times slightly higher rates than their dams, but the figures were well within limits found normal for the animals under observation. Gilbert (6) working on hematologic data of the Lacaune breed found also a trend for decreased sedimentation rates beginning with lambs 2 months old as compared to ewes 2 and 3 years of age. With the exception of one sick Toggenburg buck that died of pneumonia early in our experiment, and showed a sedimentation rate of 2mm, no values appreciably higher than one were recorded at Beltsville. On the whole, our data on sedimentation rates are comparable with those presented for sheep and goats by Bunce (3), but slightly lower than found by Kudriavtsev (11), for crude woolled sheep.

Percentage of polymorphonuclear neutrophils. The total and the differential picture of leucocytes of the experimental animals will be presented elsewhere. Here no more than a reminder of the delicate balance between the proportion of polymorphonuclear neutrophils to other leucocytes will be recorded.

Forty per cent neutrophils and over seems high both for the blood of Merino and Hampshire sheep, while 50 per cent was encountered only once, and that in a relatively delicate ewe (No. 13) at about 1 month after delivery. Unfortunately, no data for the parasite situation for the date are available. In the same Merino ewe, No. 13, 40 per cent neutrophils figured during the last month of gestation and the three following months of lactation.

A moderate infestation with *Strongyloides* and *Haemonchus* during the corresponding period may have raised the count of neutrophils, however, a similarly moderate infestation in ram No. 16 did not have such an effect. As mentioned previously, ewe No. 13 was not a thrifty animal, and there could have been several reasons for a relatively high differential count. In Merino ewe No. 33, 40 per cent neutrophils and over were encountered only during the last week of gestation.

Again, occasionally relatively high neutrophil counts, between 40 and 50 per cent, were found in two rams (Merino No. 3 and Hampshire No. 49) but these figures seem to bear no relation to the degree of infestation.

Doe No. 54 which nursed lamb No. 167, showed an unexpectedly high percentage of neutrophils in March, 1955, that is a month after it started lactating, and during a period when it showed a fairly high *Haemonchus* count. The next relatively high value was in September after lactation was terminated, but before the phenothiazine treatment could have had any effect on parasites.

Despite a temporary skin irritation in doe No. 42, and in the perfectly well doe No. 25, both on standard diet, their neutrophil ranges were lower than the does on the seasonal diet.

The differential count. Abortion in Hampshire No. 36, which took place on February 10 and at a very early stage of pregnancy, did not effect its hemoglobin, cell volume, or sedimentation values. What did show, however, was the high proportion of immature cells which reached 17 per cent approximately that of the Toggenburg buck when he ran a high fever two days before his death, and had a total leucocyte count of 20,000 cells.

The Hampshire ewe recovered after her abortion; the immature cell count went down to 9 per cent within the first month, and to zero within the next.

DISCUSSION

Considerable differences of opinion and approach to blood values exist among several investigators. After sampling various numbers of Merino, Mele, Hampshire, Suffolk, Leine and other sheep, 124 animals in all, Kleeberg (10) concluded that breeds like the Merino, Hampshire Mele, and Suffolk are characterized by high red cell counts, a relative poverty in hemoglobin, and large cell sizes, while the land races, for example the Leine, show small erythrocytes richly supplied with hemoglobin. In other words Kleeberg claims definite breed differences.

Geske (5) studied the blood picture in Karakul sheep of different ages and found that the number of both white and red cells increased to almost twice their original values as the sheep matured. Unfortunately, Geske does not mention the parasitologic picture in the sheep examined.

Broicher (2) who observed the blood of 15 sheep (breed not indicated) from the month of November to May, writes that feed as such does not influence the blood picture of the ruminants, but a high chlorine content causes a considerable shift of polymorphonuclear neutrophils to the less segmented forms.

Schulze, Christoph and Hiepe (14) tested twice certain blood values in over 50 clinically healthy sheep, representing 6 breeds and at intervals ranging from 3 to 34 days. The animals were kept at the Leipzig Zoological Gardens, that is were under the same environmental conditions. They found considerable higher erythrocyte counts and hemoglobin values in the Mouflon as compared to other sheep examined, namely, the Karakul, Zackel, Skuddle, the Mele and Merino. The Merino showed the lowest or middle lower values for both erythrocyte counts and hemoglobin content. The leucocyte situation was just the reverse, as counts in the Mouflon were among the lowest.

The Mouflon differed from the other breeds also by exhibiting a very reluctant, slow sedimentation rate.

Götze (7) observed the erythrocyte picture of 361 domestic animals, including that of 64 sheep and 18 goats, all from Dresden, or its province Saxony. The above investigator found much lower hemoglobin values in mountain sheep as compared to the mutton Merino and Hampshire and also lower erythrocyte counts and hemoglobin levels in the woolled Merino (Elektoral), than in the mutton type, Merino. Götze reports also breed differences in hemoglobin values in goats, for example, 7.79 in the African dwarf, 9.40 in native goats, and 10.21 in the highly productive (milk) Saanen.

Götze amassed sufficient data to realized that breed differences and the constitution of the animal are important, even decisive when average values are considered; nevertheless, broad allowances have to be made for individual variations. As far as erythrocytes are concerned, my experience at Beltsville with a limited number of experimental animals led me to agree with that view.

It is essential to recall here also White, Christian and Williams (16) observations on the hematology of penned Romney wethers kept on gradually decreasing rate of feed intake. The above authors found that the intake had to reach a level below 400 gr. before any changes could be detected. Pasture animals which require more energy, may behave differently as far as the amount is concerned, but the fact remains that blood values are not easily, nor quickly altered by the magnitude of the gradually altered ration.

In view of the above findings, is well as general observations, no appreciable differences would be expected in the animals kept on standard diet, as compared to those kept on a different and variable, but also satisfactory diet caused by feed alone.

Although parasitological data was recorded only at approximately two month intervals, the figures indicate that parasitic infestations were for the most part, minimal in the experimental animals. The blood picture substantiated these findings, as no anemia or other abnormalities were observed.

SUMMARY AND CONCLUSIONS

The blood picture of two groups of animals, each consisting of two Merino and Hampshire sheep of both sexes, a Merino lamb and two Toggenburg does, was observed under two different, but satisfactory dietary regimes throughout the seasons of the year at Beltsville, Maryland.

No correlation was found between hematologic values, including hemoglobin content, hematocrit and sedimentation rates, and seasonal differences existent in the normally functioning skins and hair follicles of the above experimental animals.

Despite considerable individual differences, average hemoglobin and hematocrit values tend to be representative of a breed if considered on a long range basis. Thus, Hampshires tend to show averages higher than Merinos, and Merino sheep higher than Toggenburg goats. Sexually mature ewes have higher values than their lambs.

Under Beltsville conditions, the yearly average hemoglobin (gm/100 ml), was 13.7 in the Hampshire and 13.2 in the Merino sheep as represented by both sexes; and 12.8 in the Toggenburg does. Yearly averages for red cell volume (per cent) for Hampshires were 37.8, for Merino 36.2, and for Toggenburg does 32.8, respectively.

Differential leucocytes counts and sedimentation rates have been found sufficiently uniform to suggest also their use for diagnostic purposes particularly where parasites are not the only concern. Thus, specimens are to be viewed with suspicion where neutrophils, including all degrees of maturity, comprise over 45 to 50 per cent, and where sedimentation rates are over 1 mm.

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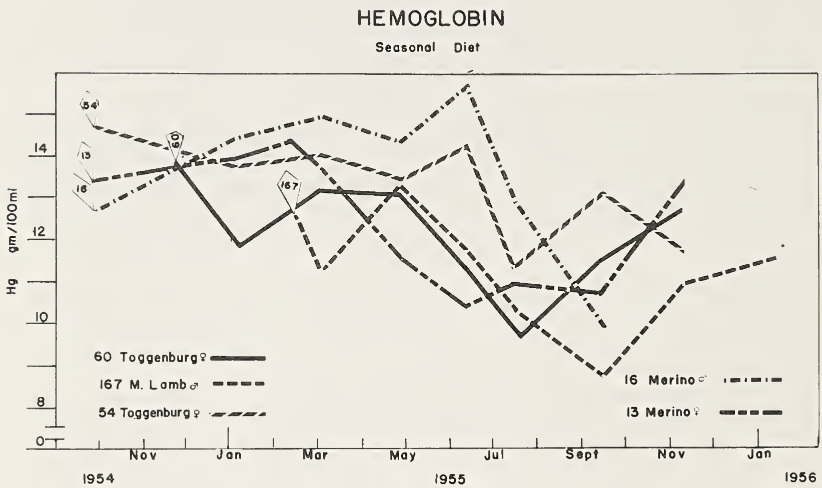


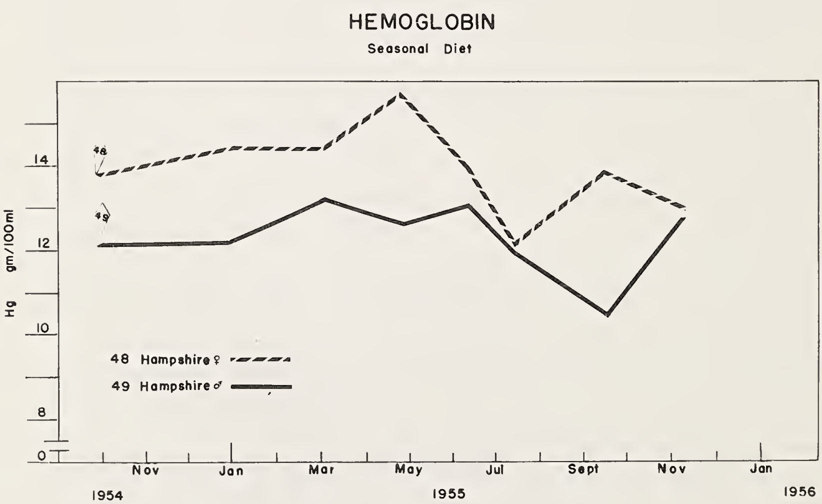
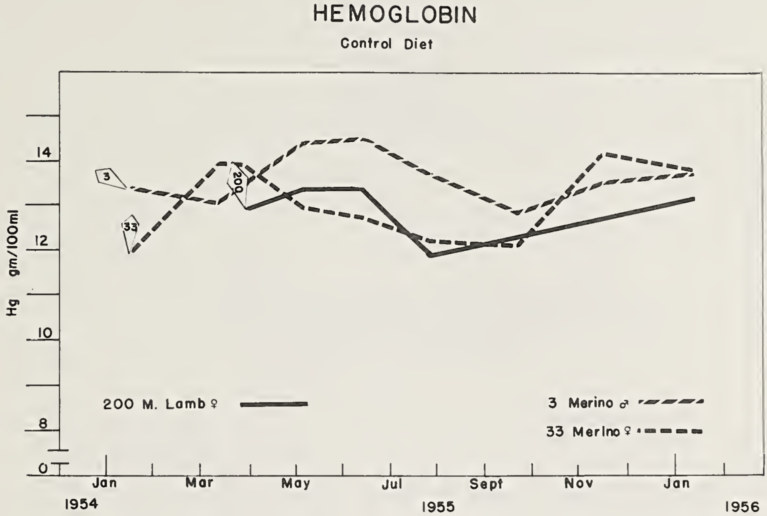


FIGURE I
Hemoglobin values in sheep and goats kept on seasonal diet.



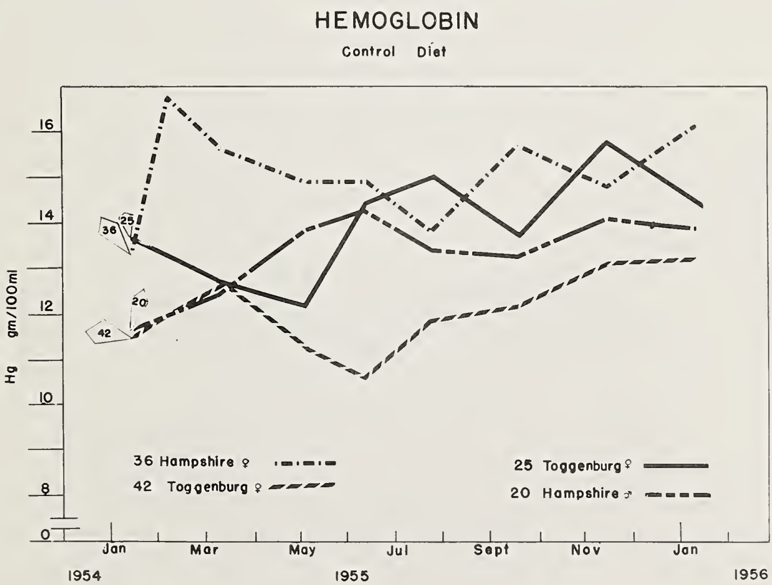
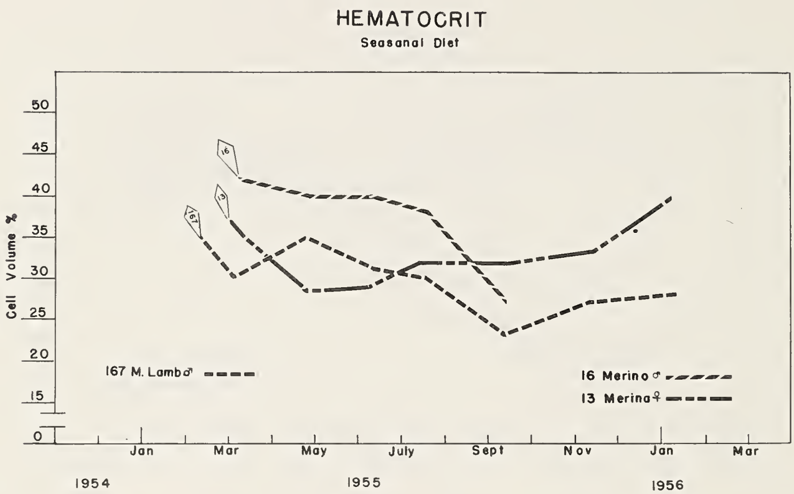


FIGURE II
Hemoglobin values in sheep and goats kept on standard diet.



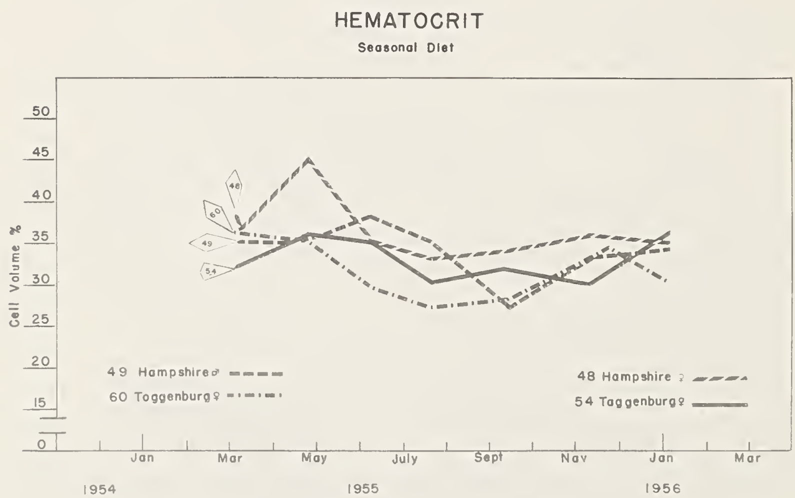
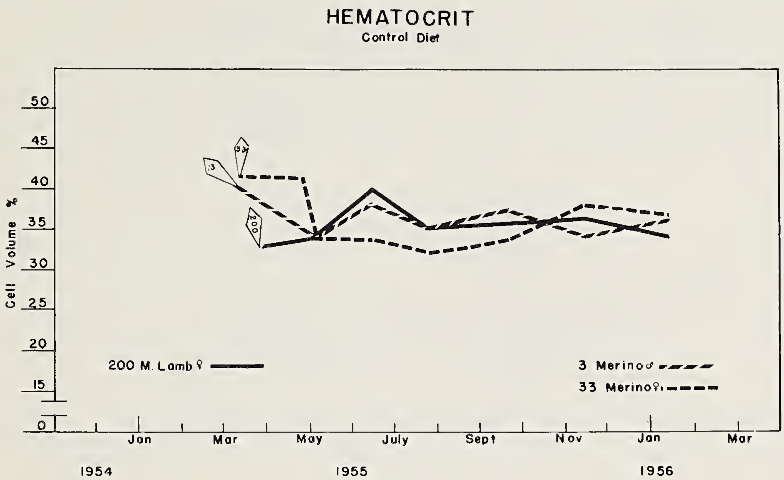


FIGURE III
Hematocrit in sheep and goats kept on seasonal diet.



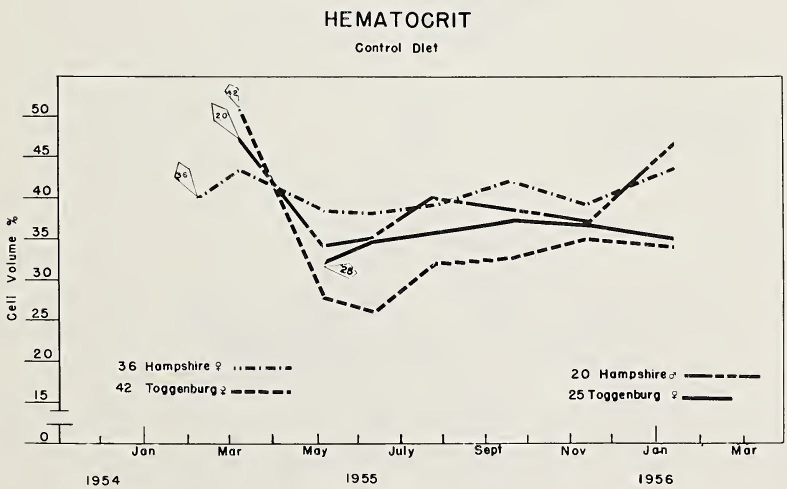
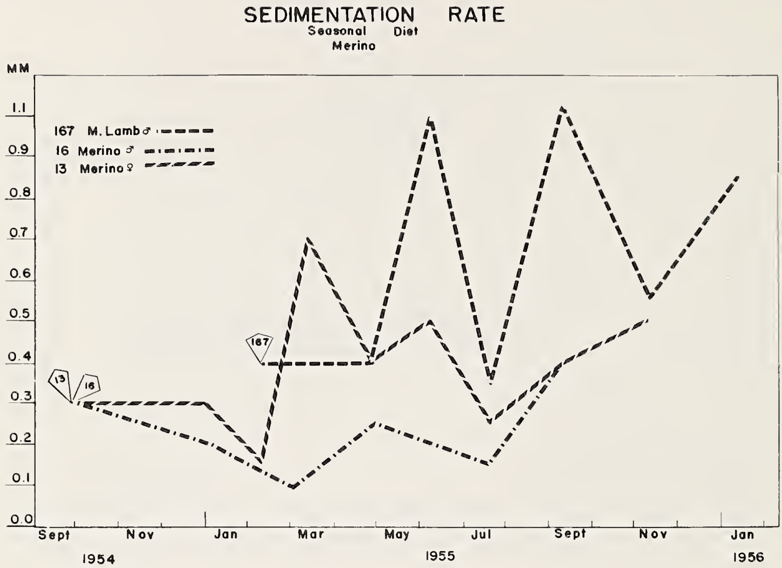


FIGURE IV
Hematocrit in sheep and goats kept on standard diet.



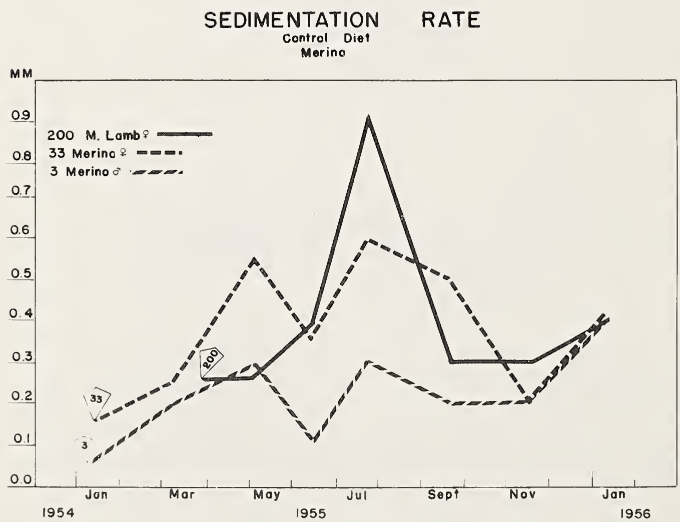


FIGURE V
Sedimentation rates in Merino sheep kept on seasonal and standard diets.

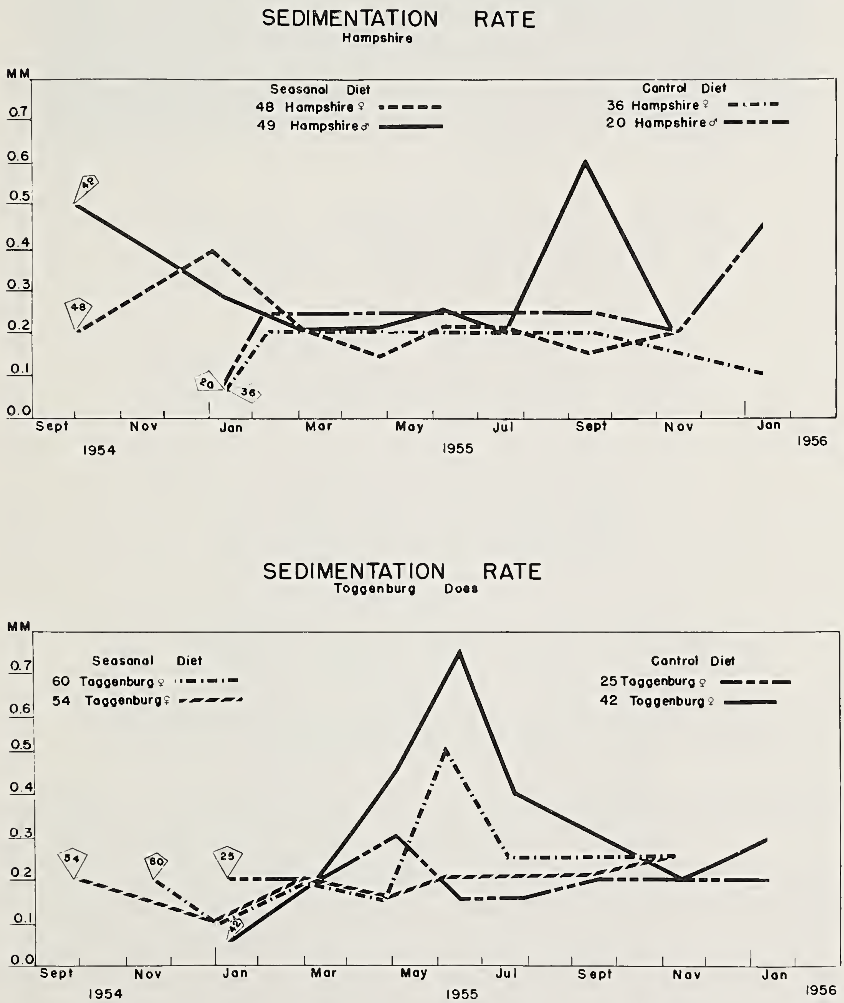


FIGURE VI
Sedimentation rates in Hampshire sheep and Toggenburg goats kept on seasonal and standard diets.

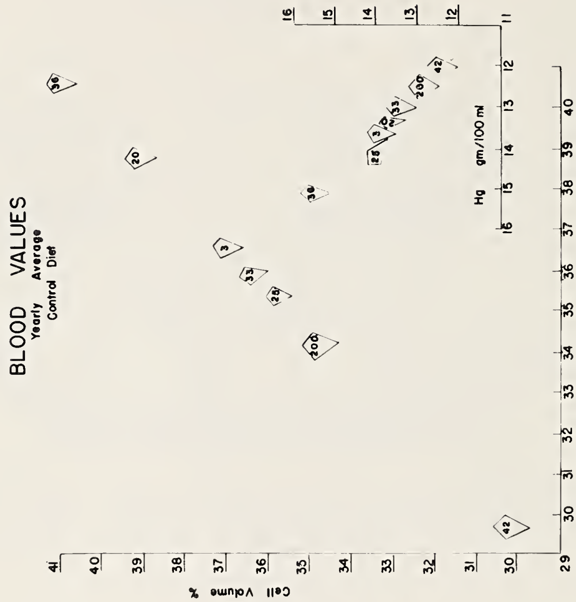


FIGURE VII

FIGURE VIII.

Yearly averages for hemoglobin and hematocrit figures in sheep and goats on seasonal and standard diets.

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