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Maine Agricultural Experiment Station

O R O N O

BULLETIN No. 221

DECEMBER, 1913

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The first paper in this bulletin presents definite measures of the degree to which the mixed milk from a large herd fluctuates from day to day in respect to its butter fat percentage and absolute fat content. The second paper describes a method of keeping pedigree records, adapted to mammals. The breeder of cattle, sheep or swine wishing to install a system of records will find this, with slight changes adapted to his needs. The last paper shows that no harm results to chicks which eat pieces of aluminum leg bands since the metal is slowly digested.

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BULLETIN 221.

I. CONSTANTS FOR NORMAL VARIATION IN THE FAT CONTENT OF MIXED MILK.¹

By RAYMOND PEARL.

The fundamental variation constants of characters which are to be the object of genetic study are certainly highly desirable, if not absolutely necessary. On this account the constants to be presented here have been worked out, in connection with the studies of the inheritance of milk production now in progress in this laboratory. It is expected that from time to time further reports will be published recording normal variation constants for other elements of milk and of milk production.

The present paper deals with the variation in fat content, both absolute and relative, of the mixed or composite milk produced by a large herd of cows. It is, of course, a well known fact that the fat content of the milk of any individual cow fluctuates, within usually rather narrow limits, from day to day. Sometimes the range of such variation in the performance of a single cow may be very wide. An example of this has recently been furnished by Fraser² in which he cites the case of a cow on an official two-day test, where, within a period of 48 hours, the butter fat varied from 2.7 per cent to 6.7 per cent, and the absolute amount of butter fat from .08 to .9 of a pound.

The causes of such fluctuations in the fat content of the milk from an individual cow are various. Many of them belong in the general category of immediate environmental circumstances, including such things as kind and amount of food,

¹Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 57.

²Fraser, W. J. Variation in Milk Yield. Breeder's Gazette, Vol. LXIV, p. 562, 1913.

weather conditions, etc. In addition there are undoubtedly many internal factors involved, such as, for example, the nervous condition of the cow, the general state of metabolism, etc.

There is a widespread belief, which has indeed found its expression in legislation, that in spite of the variation in the milk of the individual, if all the milk of the cows of a large herd be put together and thoroughly mixed, the resulting composite will not vary significantly from day to day in its fat content. It seems to be a matter of considerable importance, as a basic datum in milk production studies, to know the actual facts regarding the daily fluctuations in fat content of the mixed milk of a large herd.

The problem has recently been studied by Klose³ for a herd of 70 cattle at the Milchwirtschaftliches Institut in Proskau. Only rather crude and inadequate statistical methods are used by Klose in the analysis of his data. Under these circumstances, and because of the valuable character of the raw data which are fully given in the paper, it has seemed desirable to apply biometric methods to these figures with a view to getting an accurate and trustworthy measure of the degree of variability shown. It is the purpose of this paper to present the results of such an analysis of Klose's data.

It may be said briefly that the records analyzed come from a herd of 70 animals (breeds not specified) and cover the milk of 30 consecutive days in each of four periods of the year. The cows were milked three times a day, morning, mid-day, and evening, and a separate record kept of the milk from each milking. The data include the following items; (a) The weight of milk produced at each milking, in kilograms; (b) the specific gravity of the milk; and (c) the fat percentage of milk. All of these figures are given for the three milkings of each day separately, and then for the total milk of the whole day. The four periods chosen for the records comprised practically the calendar months of March, May, July and October. The reason for choosing these particular months was to get the greatest possible contrast in regard to feeding and

³Klose. Untersuchungen über die täglichen Schwankungen im spezifischen Gewicht und im Fettgehalt der Milch einer grösseren Herde. Milchw. Centralbl.-Milch-Zeitg. Jahrg. 42, pp. 385-392, 1913.

environmental conditions. During each of the months of March and July there was no change in the character of the food or the method of handling the animals. But in March the cows were in the barn (that is stall fed) all the time, whereas in July they were on pasture continuously. May and October represent months in which there were marked changes in the feed. In the course of the month of May the cows were put on pasture. In the month of October they were partly stall fed and partly on pasture, and other changes were made in the ration as well. In this way a contrast was afforded between the months of uniform feeding and months of varying feeding. The details as to the actual feed used may be found in the original paper.

From the data described the constants of variation given in Table 1 and 2 of this paper have been calculated, under my direction, by Mr. John Rice Miner, the staff computer of this laboratory. The constants were calculated directly from the raw data without grouping. In one case, namely the evening milk during the month of May, it is evident that there are some errors in the records as printed in the original paper. Some of these are clearly typographical. Such we have been able to correct from internal evidence in the paper itself. Even after this partial correction, however, there are evidently still left some undetected errors, either in the original determinations of the fat percentages, or in the recording and printing of these. The variation shown in the milk of this milking in *per cent* of fat is so very much greater than that of any of the other data, that it can only mean some uncorrected error. In the case of the absolute amount of fat, the errors in *per cent* are apparently compensated for to a considerable degree (cf. Table 2). In the case of variation in fat *per cent* the variation constants for the evening milk of May are given first for the data exactly as they stand, and then for the data after correction of the obvious errors.

TABLE 1.
VARIATION CONSTANTS FOR FAT PERCENTAGE.

MONTH.	Milking.	Mean.	Standard deviation.	Coefficient of variation
March.....	Morning.....	2.717±.018	0.149±.013	5.487±.479
	Midday.....	3.210±.020	.160±.014	5.156±.450
	Evening.....	2.922±.015	.125±.011	4.295±.374
	Total day.....	2.916±.015	.123±.011	4.311±.376
May.....	Morning.....	2.772±.017	0.136±.012	4.899±.427
	Midday.....	3.215±.017	.138±.012	4.292±.374
	Evening (as given).....	3.318±.038	.305±.027	9.195±.808
	Evening (partially corrected).....	3.352±.030	.246±.021	7.354±.644
	Total day.....	3.031±.013	.103±.009	3.408±.297
July.....	Morning.....	3.092±.021	0.168±.015	5.415±.473
	Midday.....	3.162±.017	.135±.012	4.257±.371
	Evening.....	3.448±.024	.197±.017	5.722±.500
	Total day.....	3.196±.013	.104±.009	3.238±.282
October....	Morning.....	3.305±.023	0.184±.016	5.573±.487
	Midday.....	3.570±.019	.156±.014	4.364±.381
	Evening.....	3.572±.021	.168±.015	4.695±.410
	Total day.....	3.445±.016	.131±.011	3.797±.331

TABLE 2.
VARIATION CONSTANTS FOR AMOUNT OF FAT.

MONTH.	Milking.	Mean.	Standard Deviation.	Coefficient of variation.
March..	Morning.....	6.205±.069	0.560±.049	9.019±.792
	Midday.....	5.634±.108	.876±.076	15.548±1.387
	Evening.....	3.910±.092	.745±.065	19.059±1.719
	Total day.....	15.691±.210	1.701±.148	10.843±.995
May.....	Morning.....	8.159±.089	0.723±.063	8.859±.778
	Midday.....	6.592±.109	.883±.077	13.395±1.187
	Evening.....	4.810±.084	.680±.059	14.139±1.256
	Total day.....	19.494±.247	2.005±.175	10.287±.905
July.....	Morning.....	7.904±.098	0.797±.069	10.082±.887
	Midday.....	6.276±.073	.595±.052	9.481±.833
	Evening.....	5.034±.070	.568±.049	11.279±.995
	Total day.....	19.283±.217	1.761±.153	9.132±.802
October....	Morning.....	8.286±.071	0.579±.050	6.990±.612
	Midday.....	5.958±.079	.644±.056	10.811±.953
	Evening.....	4.658±.092	.749±.065	16.080±1.436
	Total day.....	18.939±.197	1.602±.139	8.458±.742

From these tables the following points clearly appear:

1. In general the *percentage* content of fat is lowest in the morning milk. The fat percentage is higher in the other two

milkings of the day, and usually is highest in the evening milk. although the month of March forms an exception to this rule. That this diurnal change in percentage fat content is significant is shown by table 3, which compares the differences with their probable errors.

TABLE 3.
 SHOWING THE DIFFERENCES BETWEEN MORNING AND EVENING MILK
 IN MEAN PERCENTAGE OF FAT.

MONTH.	Difference between mean fat percent of morning and evening milk.	Difference divided by its probable error.
March.....	.205 ± .023	8.9
May (as given).....	.546 ± .042	13.0
May (partially corrected).....	.580 ± .034	17.6
July.....	.353 ± .032	11.0
October.....	.267 ± .031	8.6

The probability that the percentage fat content of the evening milk is really higher than that of the morning milk is obviously so great as to amount to certainty for all practical purposes. This result agrees with the findings of Richmond.¹

2. Without exception the *absolute* amount of fat is greatest in the morning milk, least in the evening milk, and intermediate in amount at the midday milking. This, of course, means that the amount of milk produced in the long interval between milkings is greater than in the short intervals. The differences are large and significant.

8. The difference between morning and evening milk in percentage fat content is significantly smaller in March and October, than in May and July. Owing to the uncertainty respecting the May evening milk constants stress cannot be laid on the very high difference in that month. July, however, shows the same relation, though to a less marked degree. It would on general grounds be expected that this difference would be greater on pasture than on the more exactly controlled stall feeding.

4. Taking into consideration the total day's milk it is seen that the *percentage* fat content rises steadily from March through October. The milk of this herd was a little over one-half of a per cent richer in fat in October than it was in March.

¹Cf. Analyst, Vol. 37, pp. 298-302, 1912.

This was not due to a progressively diminishing flow. The greater part of this increase in mean fat percentage occurred between July and October. This would indicate that pasture conditions (not necessarily feed alone) were a significant factor in producing the result.

5. The greatest *absolute* mean fat production per day was in May. There is, however, no significant difference in this respect between May, July and October. The influence of pasture conditions in stimulating the flow seems clear here.

6. Turning now to the variation constants, we note first that, contrary to common opinion, the *percentage* fat content of the mixed milk of a large herd exhibits a considerable variation from day to day. The standard deviations and coefficients of variation for this character in every case are more than 10 times as large as their probable errors. Certainly they cannot be considered insignificant.

7. The milk of this herd was most variable in percentage fat content in March and October and least variable in May and July. But none of the differences are significant in comparison with their probable errors. In general, it appears from these data that the degree or amount of daily *variation* in the percentage fat content of mixed milk is not significantly affected by such changes in feed and other conditions as are here involved.

8. The *absolute* amount of fat produced per day is roughly about twice as variable (compare coefficients of variation) relatively as is the percentage fat content of the milk. This result is of particular interest in relation to the rather widespread view that the variations in fat *percentage* of milk are to be accounted for in the main by fluctuations in the water content. It should be remembered that the result here set forth is for the *mixed* milk of a whole herd.

9. The relative variation in absolute fat produced, as measured by the coefficient, decreases steadily from March on through October. The amount of this decrease is, however, rather small, and in the extreme case is not certainly significant in comparison with its probable error.

10. There is no indication that the milk of any particular milking of the day is, either absolutely or relatively, significantly more variable in percentage fat content than the milk

of any other milking of the day. The total day's milk is, as would be expected, relatively somewhat less variable in fat percentage than the milk from any single milking.

II. In absolute amount of fat, the evening milk is relatively much more variable than the morning's milk. The mid-day milk occupies an intermediate position in this respect. This result would appear to indicate that during the night, when the cows are at rest, fat production in the udder is a more uniform process from cow to cow and from day to day, than during the day time when the cows are in some degree active.

While the foregoing constants and their discussion were obtained primarily for their significance in connection with further scientific studies, it is clear that they have some points of practical interest to the farmer selling milk to the creamery, to the creameryman buying milk, and to the dairy inspector enforcing a minimum fat content milk law.

II. A PEDIGREE SYSTEM FOR USE IN BREEDING GUINEA-PIGS AND RABBITS.¹

By FRANK M. SURFACE.

For use in experimental breeding an adequate yet simple method of recording pedigrees is indispensable. Further, to one who has once used pedigreed material for physiological experiments the advantages of such material are very evident. In many of the delicate biological reactions for which small mammals are extensively used it is often clearly evident that all animals do not react alike. In many cases it can be supposed that such idiosyncrasies are a matter of heredity. Accurately pedigreed material will often aid in solving otherwise very puzzling results. On the other hand, experimental breeding is just beginning to recognize the heritability of physiological characters. The keeping of accurate records for a period of time will undoubtedly throw much light upon this phase of heredity.

With this two-fold object in view the writer recently devised a system of pedigree and other records for use with small mammals. These records have been in use for a number of months and their adequacy and simplicity have been clearly demonstrated. It seems not unlikely that a description of these methods may be of interest to investigators in several fields.

The chief requirements of any pedigree system are (1) accuracy, and (2) simplicity. This simplicity should include a minimum of operations in recording an animal and an easy accessibility to all the data for any individual. So far as my

¹Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 58.

The experiments reported in this paper were carried out while the writer was connected with the Kentucky Agricultural Experiment Station.

own experience goes, these requirements are best met by a system similar to that described some years ago by Dr. Pearl and myself² for use with poultry. Methods involving the same fundamental principles have also been described by Cole³ for use in pigeon breeding.

MARKING THE ANIMALS.

The chief factor in establishing a reliable pedigree system is to mark the animals in such a way that there is no danger of mistaking them. About two years ago I corresponded with a number of breeders and laboratories using small mammals in an attempt to find what means were used for marking these animals. For physiological experiments it seemed to be almost universal to rely upon a description of color markings or in the case of solid color animals to mark them with spots of various anilin dyes. These together with cage records constitute the chief means of distinguishing the animals. A number of experimental breeders rely upon various combinations of punch marks in the ears to distinguish individuals.

None of these systems is satisfactory. Color markings, even conceding that two animals are not marked alike, require a considerable amount of time to compare the marks of the animal with the description. Any system of ear punches or anilin spots necessitates access to a key and again requires time and energy to decipher their meaning. Further, the combinations of punches and spots are quite limited so that it is very difficult to run a continuous series for any considerable number of individuals. Besides, dyes are not permanent and the ears are likely to be torn or pierced in fighting and so give trouble in reading the numbers.

Undoubtedly the most satisfactory method is to have a metal tag or band bearing a stamped number, in which case there can

²Pearl, Raymond, and Surface, F. M.—Appliances and Methods for Pedigree Poultry Breeding. Maine Agricultural Experiment Station, Bulletin No. 159, pp. 239-275. 1908, Cf., also Zeit. f. Biol. Tech. u Method Bd. 1, pp. 285-295, 1909.

³Cole, Leon J.—Methods of Keeping Pedigree Records in use at the Rhode Island Agricultural Experiment Station. Ann. Rpt. R. I. Exper. Station, 1908, pp. 317-324.

be no mistake, and the time and energy required in reading the record are reduced to a minimum. After a considerable number of experiments and many inquiries I obtained an ear tag made by T. Cadwallader at Salem, Ohio, for use with rabbits. Subsequent experiments have shown that this tag can be used very satisfactorily with guinea-pigs. A slightly different form might very well be adopted to use on even smaller mammals.

FIG. 144. Ear tags described in text.

The character of this tag is seen from figure 144. A small chick punch, such as can be obtained from any poultry supply house, is used to pierce the ear. The tag is then inserted and the points spread.

FIG. 145. Showing ear tags in place.

Figure 145 shows the ear tag in place on a young and an adult guinea pig. The tag does not inconvenience the animal

in any way and if properly inserted they do not tear out. If desired the tags may be used in duplicate, one in either ear.

In our first experiment with this tag on guinea-pigs we made the mistake of putting it too close to the head and bending the points too far back. If these points are pressed too firmly against the skin they often cause a slight irritation which may end in suppuration. In a few cases such tags were lost in the course of three or four months. However if the tag is placed just outside the heavy cartilage in the ear and the points are not pressed down too firmly we have never had any trouble of this kind. The difficulty would be entirely eliminated if the points of the tag were made a little longer.

The young guinea-pigs are so well developed at birth that they can be labeled at once without causing them any inconvenience. As a matter of fact, however, we find it more convenient to have the attendant place the pregnant females in separate cages a few days before parturition. He can then mark on the cage the date of birth and the number of young. About once a week we can then go through and label the young and make the necessary records. This involves but very little time and trouble. In the case of rabbits it is better to let the young get three or four weeks old before labeling them.

Since the principal object in growing guinea-pigs at the Kentucky Station was to furnish a sufficient supply for physiological and bacteriological work it was necessary to handle them by slightly different methods than are used by the experimental breeder. Most of the breeding is done in pens rather than in hutches. It has been found that better results are obtained if not more than 6 or 7 females are mated with one male. The pens are sub-divided by removable partitions into small areas about 2x4 feet. One male is kept in each of these pens and the females are placed in them, together with their young as soon as these latter have been tagged. When the young are about three weeks old they are removed to separate pens and the sexes separated. One pen contains surplus males which may be desirable for use in breeding. Two or more larger pens (4x4 feet), contain the surplus animals for experimental purposes. The sexes are separated, except that one male is placed in each pen of females so that if any females should remain long enough to bear young the pedigree system will remain intact.

PEDIGREE RECORDS.

For the pedigree records printed loose leaf sheets of uniform size (5x8 inches) were used. These sheets are made by the J. C. Moore Co., and are adapted to their type of binder. The sheets are readily removed or inserted when desired but at other times they are securely held in place. For the pedigree records proper, two forms are used. These are known respectively as the "Individual Description Record" and the "Mating Record."

DATE		VARIETY		ANIMAL NO.	
DATE OF BIRTH		SEX		OUT OF MATING NO.	
EXPER. NOS.				AUTOPSY NO.	
FINAL DISPOSITION					
INDIVIDUAL DESCRIPTION	COLOR SOLID		MATING NOS.		RESULT
	DOMINANT COLOR				
	COAT SMOOTH				
	" ROUGH				
	" LONG				
	" SHORT				
	EYES				
	NOSE				
	R. EAR				
	L. EAR				
	R. F. QUARTER				
	L. F. "				
	R. H. "				
	L. H. "				
	R. SIDE				
L. SIDE					
RUMP

FIG. 146. Description sheet for guinea-pigs.

Figure 146 shows, in facsimile, the individual description sheet used for guinea-pigs. At the top of this sheet are spaces for the date on which the description was made, the variety, if it is a pure bred animal, and the animal number which is the one on its ear tag. The date of birth, sex and the number of the mating from which it came are also given. Additional spaces are provided for the numbers of the experiments in which the animal may be used and for its autopsy number or final disposition if it does not come to autopsy.

On the lower portion of the sheet there is, on the left, a list of coat and color characters which it is desired to record. On the right is a space for stamping the outline figure of a guinea

pig. On this outline the limits of the principal color areas are marked. This is a great aid not only to the accuracy of description but also to the ease in referring to an animal's characters. Finally in the center of the sheet there are two columns in which are recorded the matings in which this animal enters and a brief summary of the results of each. This sheet thus provides a brief but relatively complete history of the individual.

If it is desired a record could be made of the number of the pen or hutch in which each animal is kept. This would often be a convenience in locating a particular individual. It involves the additional trouble of making a record every time an animal is transferred from one pen to another. So far we have not found this record necessary.

It should be said that the numbers are given the animals in a continuous series approximately in the order of their birth. The ear labels are purchased already numbered and for convenience in reference are used in consecutive order. No attempt is made to make the number show the pedigree. This is established through the "mating number" described below. The description sheets are arranged consecutively in the book. Thus if we should pick up guinea-pig number 124 we simply turn to page 124 and find the description and other data concerning this animal. The pedigree and breeding history of the individual are found by reference to the mating number from which it came and to the matings into which it enters as a parent.

MATING RECORD.

The key to this pedigree system is the "mating number." Every time a particular male and female are placed together an arbitrary number is given to that mating. These mating numbers are assigned in a continuous series in the order in which the matings are made. The "mating number" in itself is no indication of the pedigree but is simply an index by which the pedigree can be determined. Printed sheets similar to those described above are used for the mating records. A facsimile of one of these sheets is shown in figure 147.

IMAGING RECORD

FIG. 147. Mating record sheet.

At the top of this sheet there is space for the date on which the mating was made; a record of the individual numbers of the male and female entering into this mating and the mating number. Below are spaces for recording each offspring. The number, date of birth and sex of each offspring are entered at the time the young animal is given its ear tag. Spaces are also provided for giving references to its subsequent history.

Guinea-pigs have from one to four or more young in a litter. If the same mating is continued we stamp below the number of the last offspring the date at which the female was again placed with the male and the subsequent litter is recorded below. If the female is mated with another male this mating receives a new number and is recorded on another page. All the mating numbers of any individual are recorded on its description sheet.

Still born or aborted offspring are recorded with the date and sex but are not given individual numbers.

The mating sheets are arranged in the binder in consecutive order so that if we are referred to mating number 70 we can at once turn to this page.

INDICES.

The above two record sheets are all that are necessary in this pedigree system. However it is convenient to have at least one index. This is an index to the matings into which any animal has entered. For this the numbers of the animals are stamped in consecutive order in alternate columns on loose leaf sheets. When any animal is mated the number of this mating is entered opposite the number of the animal. Thus we can see at once all the matings into which an animal has entered without having to look up its individual description sheet.

For some purposes it is also convenient to have an index showing the mating *from* which each individual arose. Neither of these indices is necessary for the completeness of the record.

The operation of this pedigree system may be illustrated by an example. Thus we may pick up the guinea-pig bearing the number 231 on its ear tag and we wish to know its family and breeding record. We first turn to page 231 of the individual description book. This gives the animal's description, sex, date of birth, etc. The description can be verified, if we wish, by glancing at the marks on the outline figure (cf. fig. 146). This page also shows that this animal came from mating number 81 and that it has entered twice in mating number 114 and once in mating number 147. On page 81 of the mating book are given the numbers of the parents of this individual as well as its full brothers and sisters. The more remote ancestors may be traced through the parent numbers. On pages 114 and 147 of the mating book will be found all the offspring of this individual as well as the numbers of the individuals with which it was mated. If any of these offspring have been mated, such mating numbers will appear in the proper columns on these pages. In this way the grandchildren and more remote offspring can be traced at once. Reference to the experiment number and autopsy number makes the record complete at every point.

The operations in describing and recording an individual are relatively simple. Several cross references must be made but this involves but little time. The indices mentioned above aid in the ease with which this can be done.

III. ON THE ABILITY OF CHICKENS TO DIGEST SMALL PIECES OF ALUMINUM.¹

By MAYNIE R. CURTIS.

It is a matter of common observation that chicks will peck at, and sometimes swallow, small pieces of bright metal. If these have sharp points or corners, they may puncture the wall of the alimentary tract allowing the escape of some of the contents into the body cavity, and may thus indirectly cause peritonitis.

Among the several cases of peritonitis in the Maine Agricultural Experiment Station flock in the last five years four have been observed where at autopsy a sharp metal article was found still protruding from the puncture it had made in the gizzard wall. The articles were a small nail, a tack, a pin and a piece of steel watch spring. In these cases it was the sharpness of the metal which caused the difficulty. However, on account of the interposition of the gizzard a bird is less able to pass out a large indigestible article than is an animal which masticates its food. Such an article which is too large to pass through must either remain in the gizzard or must be ground up or dissolved by the digestive fluids.

The purpose of the present note is to record some observations on the fate of certain pieces of metal which when swallowed by chickens cause no disturbance in their physiological processes. The pieces of metal were aluminum leg bands. They were practically pure aluminum showing only the slightest trace of iron.²

¹Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 59.

²It is a pleasure to acknowledge my indebtedness to Prof. James M. Bartlett, Chemist of the Maine Agricultural Experiment Station, for the analysis on which this statement is based.

When chicks are taken from the pedigree incubator baskets at this Station each one is banded with an aluminum band. This is a flat strip of metal with rounded corners which is bent into a ring around the chick's leg. As the bird grows this ring is enlarged from time to time, but when the chick is six to eight weeks old it has outgrown this band altogether and is then rebanded with another type of aluminum band. This second band is adjustable. The portion of the band not used is snipped off. The size of these snips varies greatly with the size of the chickens' legs. As the chicks are rebanded the discarded bands and snips are dropped on the range. It is not unusual to see chickens pecking at them. Figure 148 shows at the top a random sample of fifteen snips cut from the second bands and at the bottom two of the discarded first bands. The one of these to the left is opened out flat and the one to the right is bent double. It may be seen from this figure that the snips are narrower than the bands.

FIG. 148. Shownig band snips and whole chick bands.

August 6, 1913, a fine strong Barred Plymouth Rock pullet, normal in all respects, was killed for material. In the gizzard

contents of this bird a bright glimmer of metal was noticed. The whole gizzard contents were then examined and found to contain fourteen aluminum leg bands or pieces of leg bands. A photograph of these is shown in Figure 149. They are in varying stages of dissolution and it is not possible to tell accu-

FIG. 149. Partly digested bands and snips from gizzard of B. P. R. ♀.

ately how many bands the bird had swallowed, as it is probable that in some cases two or more of the pieces are from the same band. Some of the fragments are undoubtedly snips. The number swallowed may be conservatively estimated as four bands and six snips. One band is still all together but is nearly separated at one point. Other pieces are very small and thin. Some have holes through them. The dissolution has evidently been accomplished by a combination of the mechanical grinding of the gizzard and the action of the hydrochloric acid of the gastric juice. The outer surfaces of the bands are covered with fine scratches while the inner surfaces show fewer scratches and more evidence of solution. After careful cleaning this entire collection of bands weighed 0.857 grams. The mean

weight of one band as it comes from a chick's leg is 0.2545 grams. The mean weight of a snip (calculated from the fifteen snips shown in Figure 148) is .0421 grams. The weight of five bands and six snips would be approximately 1.2706 grams. The difference between this and 0.957 or 0.3136 would be a rough estimate of the loss due to the digestion of the metal. This is a loss of 24.69 per cent.

This case shows that a chick may pick up a considerable quantity of aluminum and use it somewhat as it does grit, gradually wearing and dissolving it away until it becomes small enough to pass out with the feces. Aluminum is soluble in dilute hydrochloric acid. A leg band placed in a .5 per cent solution shows hydrogen bubbles on the surface, although the action is not very rapid. Further the aluminum salt formed (aluminum chloride) is non-poisonous. If the metal swallowed were not attacked by the gastric juice it would still be worn away by the grinding action. On the other hand if it were attacked and the resulting salt were poisonous (as for example zinc chloride) the result might be death from poisoning.

Two further questions suggested themselves. One was: how long had it taken the bands to reach their present state of decomposition? Secondly: was the swallowing of the bands a personal idiosyncrasy of this individual bird?

There are, of course, no data on the time the bird began to swallow bands but the rebanding of the chicks in that yard was begun the first of June or about nine weeks before the bird was killed. Therefore, some of the bands may have been in the gizzard for that length of time, but not longer.

Since the observation of the above case the gizzard contents of six other normal, healthy birds of approximately the same age as this bird running on the same range have been examined. Five of these contained no leg bands. One contained the bands and parts of bands and snips shown in Figure 150.

There are probably fewer bands and more snips in this case than in the other but the process of dissolution has evidently advanced farther and it is even more difficult to tell how many there are. The number swallowed is estimated as one band and ten snips. The weight of these at the time of swallowing would have been 0.6755 grams. Their weight after removal

from the gizzard was .301 grams. That is, the loss was .3745 grams or 55.44 per cent.

It thus seems evident that birds possess a considerable individuality in regard to the tendency to swallow pieces of bright

FIG. 150. Leg bands and snips from gizzard of B. P. R. ♀.

metal, since with equal opportunity only two of the seven birds examined had swallowed leg bands. However, in a careful search of the yards where the rebanding had been completed several weeks before, a single snip and very few first bands were found. While it is possible that some of them were completely buried in the dirt, the soil in these yards is very hard and it is probable that most of them had been eaten by the chicks.