Comparative Physiology. — *Digestion in the stomach of birds.* I. *The acidity in the stomach of young chickens.* By H. J. VONK, GRIETJE BRINK and N. POSTMA. (From the laboratory of Comparative Physiology, University of Utrecht.) (Communicated by Prof. G. KREDIET.)

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In carnivore vertebrates the *outer layer* of the stomach contents is (chiefly in the fundus) imbibed with gastric juice and in this way obtains a p_H of 2.0 to 2.8, favourable for digestion by pepsin (the optimum of pepsin varies from 1.75—2.2 in diverse animals). The superficial layer of the stomach contents is disintegrated in this way and the products of this disintegration are carried to the pyloric part by means of the gentle movements of the fundus. In the pyloric region only pepsin and no HCl is secreted. This part shows strong movements which knead the half-digested food before passing it on to the duodenum. The layer of the stomach contents which assumes a p_H favourable for the digestion is not more than 1 or 2 mm thick. At a distance greater than 2 mm from the surface, the p_H rises rapidly. The diffusion of the pepsin into the protein is very slow because of the large molecules of both.

In herbivore vertebrates the conditions are different. Because the contents of their stomach can bind far less hydrochloric acid, this diffuses rapidly through these contents. After some hours parts of the contents of a rabbits stomach, situated some cm below the surface, have already attained a p_H of 2.0 or less. The pepsin also spreads rapidly through the stomach contents. After 24 hours it can be demonstrated in the centre of the food (VONK and v. D. KROGT, 7). In the herbivore stomach the bulk of the food is not digested. Only the 1 or 2 procent of protein which it contains can be attacked by pepsin.

In omnivorous animals the conditions must be intermediate between those of carnivores and herbivores, but they have not yet been investigated adequately.

The digestion in the stomach of birds is again of a total different type. At least this is the case for those birds where the glandular and muscular stomach (gizzard) are well differentiated. The glandular stomach is to be compared with the fundus of mammals (secretion of digestive juice), the muscular stomach (gizzard) with the pyloric part of the mammalian stomach. The surface of the gizzard is covered with a sheat of coiline, a keratine-like protein, which is secreted by and adheres strongly to the wall of this stomach. During the passage through the glandular stomach the food is mixed with gastric juice. In the muscular stomach the contents are kneaded heavily; this part of the stomach can develop enormous pressures as was already known to RÉAUMUR and SPALLANZANI. The mechanical function is reinforced by small stones which are regularly taken up by the animals.

In view of these conditions it is to be expected that the p_H in the muscular stomach of birds will be more or less uniform throughout its contents. This supposition has been confirmed by the work of MENNEGA (1). For a review on this and other work on this topic see VONK (2). The p_H-values which she has found for the stomach contents of adult herons, (3.50—5.89) are surprisingly high, so high that it seems doubtful whether pepsin can act at all at these p_H-values. Nevertheless fish and meat are digested rapidly in the stômach of the heron. How this is possible is still an unsolved problem.

In young birds the p_H of the stomach-contents has never been investigated. MAC LAUGHLIN (3) found in the gizzard of adult birds 3.39 but his technique is not very exact.

The present investigation [1]) has been undertaken with the purpose to detect whether the feeding of young chickens with food, containing different percentages of protein, would lead to differences in the p_H of the stomach-contents. It has been carried out parallel with researches of other investigators who studied for practical purposes the effect of these different kinds of food on the growth of chickens (determining weight, development of feather-cover, crest and gills, general exterior etc.). These results will be published elsewhere.

The experiments were made as soon as possible after birth and 23 and 53 days after birth. A control after 100 days had to be omitted, the chickens of the investigated group having been afflicted after the third series of observations with coccidiosis.

We received the first group of chickens as soon as possible after birth. The secretion of the stomach was stimulated [2]) by feeding with food [3]) of low protein content which could not bind much of the acid secretion. Directly after feeding the animals were killed, opened and the p_H of the stomach contents determined by means of a glass electrode. A Cambridge potentiometer (Electrometer Valve Potentiometer) was used for these determinations, together with a small glass-electrode of the type used by MAC INNES and DOLE. For the description of this arrangement the dissertation of MENNEGA (1), the literature cited there and the article of VAN DEN BROEK (6) may be consulted. For each determination the electrode was checked against a standard buffer.

In this way an idea of the acidity of the stomach-contents was obtained. In some animals of the first group the p_H of the stomach was measured in

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1) We are indebted to the "Kennemer Chemische Industrie", IJmuiden, who put the greater part of the means for this investigation at our disposal.

2) The secretion of the stomach of the chicken has been investigated by FRIEDMANN (4), but he has not measured the p_H of the gastric juice or of the contents.

3) This food consisted chiefly of barley-grit.

hunger. The results of the total first series are shown in Table I, which contains also at the bottom peculiarities about the time of feeding, the contents of the stomach etc.

Average p_H-values were calculated for several groups of results. In doing so it must be born in mind that for determining the average of the p_H-values (these being logarithms) the corresponding hydrogenion-concentrations must be calculated. From these $[H^+]$-values the average and the standard-deviation can be calculated in the usual way. (The standard-deviation $\sigma = \pm \sqrt{\frac{\Sigma d^2}{n(n-1)}}$, where d is the difference between each single value and the calculated average and n the number of observations.) Finally from the average of the hydrogenion concentrations the corresponding p_H can be calculated. For comparing the results of different groups of observations, the error of the difference of these groups [4]) has to be calculated from the mean-errors of each series of determinations according to the formula $\sigma_{diff} = \pm \sqrt{\sigma_1^2 + \sigma_2^2}$, σ_1 and σ_2 being the mean-errors of each group. According to the rules of these calculations a difference is considered to be essential (significant) if it exceeds 2 to 3 times its error. In view of the relatively small amount of observations in this case a difference can only be taken as essential if it exceeds 3 times its error. All these calculations have to be performed on the hydrogenion concentrations and not on the p_H-values.

By means of these calculations the following results have been obtained for Table I:

Average of all the glandular stomachs:		
	p_H 2.66 (+ 0.38 or —0.20);	$[H^+] = 0.002\,191 \pm 0.001\,284$
id. gizzards:	p_H 2.86 ($\pm$ 0.08);	$[H^+] = 0.001\,392 \pm 0.000\,253$
Difference		$= 0.000\,799 \pm 0.001\,309$

The difference of 0.000799 between the glandular stomachs and the gizzards is not essential, being in fact even smaller than its error.

Moreover the averages of all the gizzards and of all the glandular stomachs of fed animals were compared with each other:

Average gizzards of all fed animals		
	p_H 2.77 $\pm$ 0.06;	$H = 0.001\,708 \pm 0.000\,235$
id. gl. stomachs	p_H 2.89 $\pm$ 0.01;	$H = 0.001\,293 \pm 0.000\,036$
Difference		$= 0.000\,415 \pm 0.000\,238$

This difference is neither significant.

The results for the animals in hunger (X, XI, XII) were:

Average gizzards	p_H 2.77 (+ 0.11 or —0.10);	$H = 0.001\,706 \pm 0.000\,392$
,, gl.stom.	p_H 4.25 (+ 0.19 or —0.13);	$H = 0.000\,056 \pm 0.000\,019$
Difference		$= 0.001\,650 \pm 0.000\,392$

4) This difference must be calculated again from the hydrogenion concentrations.

This difference should be considered as significant, but in view of the small amount of observations (especially for the glandular stomach) and of the results for the observations on all the stomachs and those of the fed animals, we cannot consider it to be of real importance.

TABLE I.

p_H in the first stages of life (3—7 days). Born May 1; arrived May 3.

	May 4		May 5							May 8		
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Crop, coecum	4.45	4.20	4.80	4.70	4.10	4.70	4.00	5.00	4.10	5.85	4.85	4.85
„ transition	—	4.90	5.80	4.75	4.50	5.10	5.00	5.25	4.60	6.25	—	5.10
Gland. stomach	3.70	4.45	1.85	2.45	2.10	4.80	4.50	5.50	3.65	4.25	4.65	4.05
Musc. stomach l. (gizzard)	3.00	3.50	2.30	2.75	—	3.35	2.90	3.60	3.00	3.05	3.00	2.50
Musc. stomach r. (gizzard)	3.60	3.50	2.65	3.30	—	3.05	2.40	3.60	3.05	3.05	2.60	2.75
Beginn. duodenum	5.20	5.70	6.00	5.75	6.15	5.70	5.45	6.05	6.05	6.80	6.55	6.85
Fresh food mixed with some water	5.60											

Arrangement and particulars of the experiments in Table I.

Feeding: 3 May. All animals 14.30 water; 14.45—15.00 and 18—18.30 food.
4 May. All animals: 8.30—10.00, 11.30—12.00, 13.30—14.30 food; then I and II killed and measured, the others food at 15.30—16.30.

Observations: I crop moderately filled; gland. stom. empty; gizzard moderately filled;
II crop strongly filled; gland. stom. distally filled; gizzard moderately filled.

If the glandular stomach is not mentioned, it was empty. The contents of the gizzard are generally dry, consisting of chaff, more or less sand, some meal and broken grain.

5 May. IV and V no food; the others fed at 9.00—9.15.
III killed and measured at 9.15—9.45. Crop and gizzard well filled.
IV and V k. and measured at 10.15. IV crop empty, gizzard much sand; V crop filled, gizzard as IV.

10.45—11.15 the others fed; 11.15 VI k. and m.; crop and gizzard moderately filled.
13.00—13.30 the others fed; 13.30 VII k. and m.; crop and gizzard well filled.
14.30—15.00 the others fed; 15.00 VIII k. and m.; crop and gizzard well filled.
16.00—16.30 the others fed; 16.30 IX k. and m.; crop well filled; gizzard nearly empty.

May 6 and 7. Animals X, XI and XII until 7 May 20.00. After that animals without any straw, only with water.

May 8. 10.15. X, XI and XII killed and measured. Crop and gland. stomach empty, some contents in gizzard.

I, II, III, VI, VII, VIII, IX are fed animals.

X, XI, XII are animals in hunger.

IV and V had no food during 14 hours but could pick up pieces of straw and some remnants of previous feeding.

The chief result of the total series of observations of Table I is the low acidity of the stomach contents (both for gizzard and glandular stomach) in fed animals as well as for the total of all animals. This acidity (averages varying between p_H 2.66 and 2.89) is far lower than that of the content of the gizzard and muscular stomach of all the adult birds formerly measured by MENNEGA. This result demonstrates that at least for young chickens a strongly acid gastric juice is secreted quite comparable in acidity to that of mammals.

We now proceed to the measurements carried out on animals which had been fed after birth on the farm with food containing different percentages of protein. These three kinds of food are indicated as —30, —25 and —20; —30 having the highest, —20 the lowest content of protein. The composition of these foods may be seen from the following list:

	Food — 30	Food — 25	Food — 20
Maize-flour	4.—	4.—	5.—
Barley-flour	10.—	11.—	13.—
Oat-meal	7.—	8.5	10.—
Bran	7.—	8.5	10.—
Fish-meal	3.—	3.—	3.—
Animal-meal	6.—	6.—	6.—
Yeast	1.—	1.—	1.—
Minerals	1.—	1.—	1.—
Grass-meal	4.—	4.—	4.—
Oat-grits	34.—	36.—	39.—
Milk powder	5.—	5.—	5.—
Meat-meal	18.—	12.—	3.—
Vitamine-mixture	0.05	0.05	0.05

The results of the measurements 24—25 days after birth are given in Table II.

The comparison of several averages showed the following results:

Average of all the gizzards: p_H 2.77 ± 0.06; [H+] = 0.001 708 ± 0.000 235
,, ,, ,, gland.stom.: p_H 4.06 ± 0.16; [H+] = 0.000 094 ± 0.000 032

Difference = 0.001 614 ± 0.000 237

This difference exceeding more than 6 times its error, is essential and therefore the contents of the gizzards are far more acid than those of the glandular stomachs.

Average of all the gizz. (food —30):
p_H 2.49 ± 0.06 ; [H+] = 0.003 228 ± 0.000 445
Average of all the gizz. (food —20):
p_H 3.08 (+ 0.08 or —0.07); [H+] = 0.000 828 ± 0.000 141

Difference = 0.002 400 ± 0.000 467

This difference is essential.

Average of all the gizz. (food —30)

p_H 2.49 ± 0.06 ; $[H^+] = 0.003\,228 \pm 0.000\,445$

Average of all the gizz. (food —25)

p_H 3.00 (+ 0.10, or —0.08); $[H^+] = 0.001\,001 \pm 0.000\,199$

Difference $= 0.002\,227 \pm 0.000\,487$

This difference is essential.

Average of all the gizz. (food —25)

p_H 3.00 (+ 0.10, or —0.08); $[H^+] = 0.001\,001 \pm 0.000\,199$

Average of all the gizz. (food —20)

p_H 3.08 (+ 0.08, or —0.07; $[H^+] = 0.000\,828 \pm 0.000\,141$

Difference $= 0.000\,173 \pm 0.000\,244$

This difference is smaller than its error.

TABLE II.

p_H 24—25 days after birth, after feeding with food with different percentages of protein.

Data	May 25.10.00 h					May 26.10.00 h					May 26.14.00 h	
No. food	—30	—30	—30	—25	—20	—30	—25	—20	—20	—20	—25	—25
No. animal	I	II	III	I	I	IV	II	II	III	IV	III	IV
Crop, cran.	5.29	5.32	5.44	5.46	5.76	3.86	5.30	5.15	5.56	5.08	5.61	5.68
„ coecum	4.77	5.44	5.46	5.60	5.37	3.62	5.14	4.79	5.56	4.85	4.78	5.49
„ caudal	5.15	5.45	5.32	5.44	5.48	5.20	5.00	5.25	5.15	4.94	5.51	5.57
Glandular stomach	4.48	4.16	3.39	3.88	4.31	3.80	4.54	4.00	4.28	4.60	4.46	4.98
Condition	e	e	f	f	e	fl	f	e	fl	f	e	e
Musc. stomach (gizzard)												
conditon	m.fl	s.fl	mo.fl	mo.fl	s.fl	n.fl	s.fl	mo.fl	mo.fl	n.fl	s.fl	v.m.fl
Left	2.46	2.43	2.47	2.89	3.40	2.14	3.38	3.45	2.86	3.25	2.71	2.62
Dorsal	2.63	2.74	2.88	3.20	3.68	2.18	3.12	2.94	3.00	2.90	3.09	3.68
Right	2.82	2.33	2.93	3.14	3.75	2.39	3.12	3.14	2.73	3.12	2.51	3.01
Ventral	2.46	2.77	2.65	3.50	—	2.52	3.35	3.37	2.76	3.38	4.04	2.94
Food		5.68							5.70		5.64	

n.fl = no fluid, s.fl = small amount of fluid, mo.fl = moderate amount of fluid, m.fl = much fluid, v.m.fl. = very much fluid, e = empty, f = full, fl. = fluid.

Arrangement and particulars of the experiments in Table II.

Feeding: 24 May all animals from 17—21 h.

25 May all animals from 8.30—10.00; then killed and measured food —30 nos I, II and III, food —25 no I, food —20 no I; the others fed until 21.00.

26 May all remaining animals from 8.30—10.00; then killed and measured food —30 IV, —25 II and —20 II, III and IV.

The two remaining animals fed until 14.00, then killed and measured (—25 III and IV).

The p_H of the three kinds of food is practically the same.

In the objects —25 III and IV which have been fed during 5.30 hours before the measurements were taken, the deviations of the p_H-values per animal are much larger, than for the animals which were killed after 1.30 hour of feeding. It is therefore advisable that the feeding be continued not too long a time before observation takes place.

It seems therefore that the food —30, richer in protein, causes a decidedly higher acidity in the gizzard than the food poorer in protein. This is the more striking because, if on the three kinds of food an equal amount of gastric juice of the same acidity were secreted, the food richer in protein would show the higher p_H. The contrary is the case and therefore either the food richer in protein must cause the secretion of a larger quantity of stomach-juice, or of a stomach-juice of higher acidity than that secreted on the food with less protein. Both these factors could also coöperate. The difference between the foods —30 and —25 (—25 with a medium amount of protein) is also real. The difference between food —25 and —20 is not essential, but nevertheless there is a difference in the same direction as that between —30 and —25. As to the possibility of pepsin-action the result is that for the food richer in protein the conditions (average p_H 2.49) are very good and for the others (3.00 and 3.08) tolerable.

TABLE III.

p_H 52—53 days after birth, after feeding with food with different percentages of protein.

Data	June 22.9.30 h					June 23.9.30 h						
No. food	—30	—25	—25	—25	—20	—30	—30	—30	—25	—20	—20	—20
No. animal	V	V	VI	VII	V	VI	VII	VIII	VIII	VI	VII	VIII
Crop, cran.	4.54	4.08	4.41	4.48	5.26	5.14	5.06	5.15	4.11	4.81	5.33	4.50
„ coecum	4.72	4.42	4.36	4.86	5.33	4.09	5.10	4.96	4.60	5.67	5.66	5.00
„ caudal	4.79	4.29	4.45	4.72	5.10	4.62	4.81	5.24	4.42	5.35	5.53	5.24
„ transition ("Strasse")	4.46	4.72	4.56	4.62	5.41	4.40	—	5.20	—	5.38	5.66	5.34
glandular stomach												
Condition	f	e	fl	e	f	p	p	p	fl	fl	fl	p
Cranial	3.44	4.48	4.84	4.42	4.55	4.28	5.25	4.80	4.86	4.68	4.53	4.48
Caudal	3.93	3.70	4.75	4.29	3.89	4.22	4.62	4.65	4.58	4.53	4.30	4.80
Musc. stomach (gizzard)												
Condition	m.fl	n.fl	mo.fl	s.fl	s.fl	m.fl	m.fl	m.fl	m,fl	n.fl	n.fl	mo.fl
Left	—	2.40	3.46	3.88	3.54	3.58	3.38	2.94	3.05	3.22	3.40	3.44
Dorsal	3.61	—	3.90	3.57	3.45	3.80	3.40	3 40	2.96	3.72	3.46	3.67
Right	—	2.75	3.80	3.08	3.30	3.84	3.18	2.74	2.93	3.52	3.36	3.78
Ventral	3.34	2.52	3.56	3.48	3.42	3.92	3.44	3.00	2.64	3.19	3.52	3.68

n.fl = no fluid, s.fl = small amount of fluid, mo.fl = moderate amount of fluid, m.fl = much fluid, e = empty, f = full, fl = fluid, p = pulpy.

Arrangement and particulars of the experiments in Table III.

Feeding: 21 June from 16—22 h.
22 June from 8.00—9.30, then the animals indicated in the table under 22 June killed and measured.
The remaining chickens were fed until 22.00 h.
23 June fed from 8.00—9.30; then the animals under June 23 killed and measured.

The same experiments were performed 52 and 53 days after birth. These results are shown in Table III. The comparison of several averages showed the following results:

Average of all the gizzards
p_H 3.18 (+ 0.08 or —0.07); $[H^+] = 0.000\,667 \pm 0.000\,117$
Average of all the gl.stom.
p_H 4.24 (+ 0.14 or —0.11); $[H^+] = 0.000\,058 \pm 0.000\,016$

Difference $= 0.000\,609 \pm 0.000\,118$

This difference is essential and therefore like in Table II the average acidity of the gizzard is decidedly lower than that of the glandular stomach. However the acidity in the gizzards of this Table (III) is lower than that of the gizzards in Table II. We return to this point later on.

The comparison of the gizzards containing different kinds of food does not show the same regular results as that in the experiments of Table II. If we take as essential a difference between two averages which exceeds 3 times the error of this difference, we must conclude that there are no real differences between the acidity of the gizzards containing the three different kinds of food. This may be seen from the following calculations:

Average of all the gizz. (—25)
p_H 2.95 (+ 0.14 or —0.10); $[H^+] = 0.001\,1208 \pm 0.000\,3051$
Average of all the gizz. (—30)
p_H 3.30 (+ 0.09 or —0.08); $[H^+] = 0.000\,5039 \pm 0.000\,1011$

Difference $= 0.000\,6169 \pm 0.000\,3214$

Average of all the gizz. (—25)
p_H 2.95 (+ 0.14 or —0.10); $[H^+] = 0.001\,1208 \pm 0.000\,3051$
Average of all the gizz. (—20)
p_H 3.45 $\pm$ 0.04 ; $[H^+] = 0.000\,3564 \pm 0.000\,0348$

Difference $= 0.000\,7644 \pm 0.000\,0314$

Average of all the gizz. (—30)
p_H 3.30 (+ 0.09 or —0.08); $[H^+] = 0.000\,5039 \pm 0.000\,1011$
Average of all the gizz. (—20)
p_H 3.45 $\pm$ 0.04 ; $[H^+] = 0.000\,3564 \pm 0.000\,0348$

Difference $= 0.000\,1475 \pm 0.000\,1069$

In so far as any significance can be attributed to these differences, we see that the greatest difference (greater than 2 times its error) exists between the animals fed with food —25 and those fed with food —20. However the gizzards of animals with food —25 are (quite contrary to the results of Table II) more acid (though not significantly) than those of the animals with food —30. The most justified conclusion we may draw from these results, is that in this stage there are no real differences between the results with the different kinds of food. This is in agreement with the fact that the average acidity of all gizzards of the animals of Table III is significantly less than that of the animals of Table II, as may be seen from the following figures:

Average of all the gizz. Table II
p_H 2.77 ± 0.06 ; [H+] = 0.001 708 ± 0.000 235
Average of all the gizz. Table III
p_H 3.18 (+ 0.08 or —0.07); [H+] = 0.000 667 ± 0.000 117

Difference = 0.001 041 ± 0.000 263

This difference exceeds about 4 times its error. It is the more reliable because the number of the determinations (47 for all the gizz. Table II and 45 for all the gizz. Table III) is much larger than that of the determinations in the experiments with different kinds of food.

Finally we had at our disposal 11 adult cocks for our experiments. These animals were fed with different kinds of food. Six of them were fed with mixed chickenfood (containing meat-meal, barley-grit-and meal etc.) as used in chicken feeding. One was fed with raw minced potatoes, two were fed with earthworms and some meat, two with mixed food and some earthworms. We propose to deal with these experiments extensively in a following communication. We may however compare the averages obtained in these experiments with those of the young animals in the present paper. As an average of the determinations on 8 animals fed with mixed food with or without worms (in total 72 determinations) we obtained a p_H of 2.96 (+ 0.05 or —0.04) corresponding with a hydrogenion concentration of 0.00108 ± 0.000114. The difference of this value with the average of the animals of Table II was 0.000628 ± 0.000261. In view of the great amount of observations (72 for the adults and 47 for Table II) we may consider this difference as real.

If we include in the observations of the adults all the fed animals viz. also one animal fed with minced potatoes and two animals fed with meat and worms we obtain a somewhat higher average of 0.000867 ± 0.0000983 corresponding to a p_H of 3.06 (+ 0.05 or —0.04), because especially the animals fed with meat showed higher p_H-values. The difference with the average of Table II is then more pronounced, whereas a real difference with the results of Table III does not exist [5]).

We may therefore come to the final conclusion that the acidity in the investigated adult animals appears to be somewhat lower than that of the animals in Table III but that this difference (if all the adult fed animals are included) is not real. Only in the first stages of life (2 to 23 days after birth) a decidedly lower acidity of the stomach contents is found. After 52 days the conditions do not differ from those of adult animals.

[5]) For the difference between the values of Table III and of the 8 adults fed with mixed food we get 0.000413 ± 0.000163, which can be considered as essential (in view of the rather large amount of observations).

Discussion. We may now try to answer the question, whether the acidity in the stomach of the chickens is sufficient to enable a good action of pepsin. This answer can only be a prelimary one, as the optimum of extracts of the glandular stomach of the chickens has never been determined. We intend to publish the results of this determination in our next article. There is however no reason to expect that this optimum will be situated far beyond the range of p_H 1.75—2.40 which has been found until now for different animals (VONK, 8, MENNEGA, 1). As may be seen from the average of Table II for the young animals the p_H of the stomach contents (2.77) is near the probable optimum.

For the older animals (Table III: 3.18, adults 3.06) the p_H of the contents will probably show a fair deviation from the optimum. From former results of one of us (VONK 8) it may be concluded that at p_H 3.0 the action of pepsin is about 12 times slower than at its optimum and at p_H 3.2 about 16 times. However it has been demonstrated in the same paper that stirring of the digestive mixture has a strong accelerating influence on the peptic action. Now in the gizzard of the chicken very strong movements take place which develop an enormous pressure. Our preliminary conclusion therefore is, that the conditions in the chicken's stomach regarding p_H and movement are sufficient to enable a good peptic digestion. Further research on the accelerating action of strong pressures on the action of pepsin is desirable.

The rapid digestion in the stomach of the adult heron remains to be explained as the p_H-values found by MENNEGA are higher and the movements (as far as known) negligeable in comparison with those of the grain consuming birds.

Summary.

The p_H of the stomach (gizzard) contents of young chickens were determined in order to see whether there is a difference in these p_H-values when food with different percentages of protein was given. Such difference has only been found about three weeks after birth, the food with the highest protein content showing the lowest p_H-values. About 7 weeks after birth these differences have disappeared.

The contents of the gizzard always show a higher acidity than that of the glandular stomach.

In young animals (23 days) the contents of the gizzard show an average p_H of 2.77, in animals 52 days after birth the average p_H of the gizzard has risen to p_H 3.18. In adult cocks we found an average p_H of the gizzard of 3.06. This figure does not differ essentially from the p_H (3.18) after 52 days.

The p_H in young chickens (until 3 weeks) enables a strong action of pepsin. In adult animals this action must be slower because of the higher p_H. Probably this is compensated by the promotion of the digestion through the strong movements of the gizzard.

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