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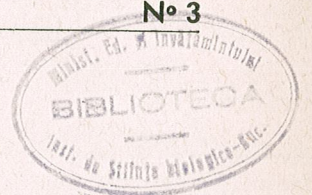
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RECENT ADVANCES IN TELEOST TAXONOMY AND
THEIR IMPLICATIONS ON FRESHWATER
ZOOGEOGRAPHY

BY

P. BĂNĂRESCU

Adopting the recent (1966) classification of Teleosts by Greenwood, Rosen, Weitzman and Myers [8], the families of primary division freshwater Teleosts are ascribed to fewer but larger high taxa than formerly accepted, the principal being the Osteoglossomorpha, Ostariophysi and Percopsiformes. The dispersal of Ostariophysi is more recent than that of most non-Ostariophysi. Continental drift gives the best explanation to the distribution of most taxa of freshwater fishes. The distribution of Percid genera shows that Europe has more basic groups but fewer species than North America; that of the Cyprinid and Cobitid subfamilies, that the East Asian fish fauna is closer to the South Asian than to the Holarctic.

The most recent comprehensive study on the zoogeography of freshwater fishes of the world is that by Ph. Darlington [6], who gives also an almost complete account of the fish families occurring in fresh waters; he omitted but two families restricted to fresh water: the Australian Gadopsidae and the New Zealand Cheimarichthyidae. Only two families of freshwater fishes were described since 1957, both from tropical Africa: *Denticipitidae* Clausen, 1959 and *Grasseichthyidae* Géry, 1964, but the last named was included by Greenwood et al. [8] within the Kneriidae. Many subfamilies of Characoidei were raised by Weitzman (in Greenwood et al. [8]) to family rank, but this did not change Darlington's general world scheme of distribution of freshwater fishes. A few comprehensive papers were published since 1957 on the origin and dispersal of freshwater fish faunas of several regions: Europe and adjacent countries (Bănărescu [1]), New Zealand (Mc Dowall [9]), Central America (R. R. Miller [10]; G. S. Myers [13]), but neither these papers change much of Darlington's scheme, except that Bănărescu pointed out the dissimilarity between the Euro-siberian and East Asian fauna and that Myers rejected Darlington's presumption of remote North

American origin of the ancestors of the speciose South American Ostariophysean fauna and suggested continental drift to explain the close relationship of South American and African fish faunas.

Each zoogeographical synthesis is based on the systematics of the taxa under consideration and Darlington adopted the classification of Teleosts in general use in 1957, which was that proposed by Berg [4] in 1940 but slightly modified. Yet Greenwood, Rosen, Weitzman and Myers [8] recently proposed a quite different classification, whose main features are the splitting of the former Clupeiformes, the erection of the superorder Osteoglossomorpha (which includes, besides the Osteoglossidae, further primary freshwater groups: the African Pantodontidae and the Mormyriiformes, the South Asian and African Notopteridae and the North American Hiodontidae), the exclusion of the Amblyopsidae from the Cyprinodontiformes and their inclusion within the Percopsiformes and finally the erection of the superorder Atherinomorpha — with a single order, Atheriniformes — including also the former Beloniformes and Cyprinodontiformes.

This new classification has broader zoogeographic implications.

The newly erected Osteoglossomorpha include primitive families of primary division freshwater fishes, formerly ascribed to distinct orders and suborders. We were justified, until recently, to think that these families reached, in very old times, the fresh waters independently from distinct marine ancestors. Yet their lumping shows that their ancestors differentiated from each other in fresh waters. The newly erected Osteoglossomorpha is, besides the Ostariophysii, the second large group of Teleosts entirely confined to fresh waters. Most of its families inhabit the Southern Hemisphere, but the Hiodontidae are North American. This distribution suggests rather continental drift, but there is also the alternative of former northern distribution, followed by dispersal over southern continents and disappearance in the North.

The inclusion of Amblyopsidae in the Percopsiformes proves that this family belongs to the primary and not to the secondary division of freshwater fishes, as Darlington believed. By including also the Amblyopsidae, the Percopsiformes become a much more important order of primary freshwater fishes than formerly considered.

The three subantarctic families of freshwater (partly diadromous) fishes — Galaxiidae, Retropinnidae, Aplochitonidae — whose distribution bears so much similarity, were ascribed by Berg the first to a distinct order, the two others to the suborder Salmonoidei of Clupeiformes, together with the Salmonidae and related northern families of prevailing diadromous fishes, but also with some exclusively marine (some even deep sea!) families. In the new classification, these three families are ascribed to a distinct suborder — Galaxioidei — of the newly erected Salmoniformes, the fourth family of this suborder being the North Pacific marine and diadromous Salangidae. This suggests a common origin of the three subantarctic families and, as to their kinship with the Salangidae, a descent from some group of Pacific prevailing diadromous fishes, whose descendants disappeared in the tropics and survived in northern and southern cold and temperate regions, like the lampreys and other groups of "bipolar" organisms.

The distribution of these families in South Australia, Tasmania, New Zealand, New Caledonia and southern South America is explained by most authors (including Darlington and Mc Dowall) by dispersal through sea, a few of their species spawning in sea water or being at least salt-tolerant. Yet Stokell [16] rejects this explanation, because there are too few representatives of Galaxiidae spawning in sea — practically only *Galaxias attenuatus* — and some genera confined to fresh waters on remote land masses have no marine representatives. But Stokell agrees that neither southern land bridges nor continental drift gives a better explanation of this peculiar distribution and concludes that there is presently no satisfactory explanation of it. I think the paucity of diadromous representatives is not an argument against dispersal by sea, especially when one considers that several archaic groups have more chance of survival in fresh waters than in sea and that from a single diadromous species, several species can arise at a relatively rapid rate, by successive isolation of landlocked colonies.

The families of the primary division of freshwater Teleosts belong to the following taxa, as recognized in the new classification:

Two superorders consisting exclusively or almost exclusively of such families: Osteoglossomorpha (2 orders, 6 families) and Ostariophysii (2 orders, 4 suborders, 56 families: 16 of Characoidei, 4 of Gymnoidei, 7 of Cyprinoidei, 29 of Siluriformes, besides two other families of secondary marine Siluriformes).

Two orders: Percopsiformes — three families in North America — and Channiformes (= Ophicephaliformes) with one family in South and East Asia and in Africa.

Four suborders: one of Salmoniformes — Esocoidae, with 3 families in the Holarctic Region — and three of Perciformes: Anabantoidei (4 families), Luciocephaloidei (1 family), Mastacembeloidei (2 families) all mainly South Asian with a few representatives in East Asia and in Africa.

Six families belonging to prevailing marine suborders: Denticipitidae (apparently the most primitive family of Clupeiformes as restricted by Greenwood et al.), Kneriidae and Phractolaemidae (belonging, together with the marine Chanidae to the suborder Chanoidei of Gonorhynchiformes), all three in Africa and three families of Percoidei: Percidae (Holarctic), Centrarchidae (North American) and Nandidae (Oriental, African and Neotropical).

There are 5 other families restricted to fresh water, yet considered by most authors (especially Myers in several papers and Darlington [6]) of marine origin, respectively as belonging to the peripheral group of freshwater fishes: one of Atheriniformes (Melanotaeniidae — Australia and islands belonging to its continental shelf), two of Perciformes (Gadopsidae — South Australia and Tasmania — and Cheimarichthyidae — New Zealand) and two of Scorpaeniformes (Cottocomephoridae and Comephoridae, both restricted to the Baikal Lake, the first one also in a few adjacent waters).

The inclusion of these 5 families within the group of peripheral freshwater fishes is rather a matter of convenience. They are ascribed to this group because of the probable derivation of Cottocomephorinae

and Comephorinae from marine Cottidae and of the occurrence of the three other families in countries inhabited chiefly by marine derivatives and which lack families of the primary division freshwater fishes common with other continents, except the archaic Ceratodidae and Osteoglossidae. The remote ancestors of each of these families were undoubtedly marine derivatives which reached the fresh water independently from other freshwater taxa. But the same is true also for other freshwater families of the primary group belonging to prevailing marine orders or suborders, such as Percidae, Centrarchidae and Nandidae. These three families for example belong, as well as the Gadopsidae, to the large suborder of Percoidei, consisting mostly of marine families; each of the freshwater family derived from a marine species which colonized the fresh waters and became the ancestor of a distinct family. Why should we consider three of these families as primary freshwater and the fourth as peripheral? The only valid argument in considering the Gadopsidae as peripheral, is the fact that they remained restricted to a few adjacent river drainages — probably not far from that reached by their remote marine ancestor — while the three other families spread on a large continental range and even reached, by continental route, two continents (Percidae) or even three (Nandidae). The same argument is valid for the Cottocemphoridae, Comephoridae and Cheimarrichthyidae with restricted range, but not for the wide-ranged Melanotaeniidae, which occur on almost the whole Australian shelf, but nowhere outside it, as the Cobitidae, Cyprinidae, etc. do not occur beyond the Sunda shelf. De Beaufort is thus justified in ascribing the Melanotaeniidae to the primary division of freshwater fishes.

The general conclusion of this reviewing of the families and higher taxa of primary freshwater fishes is that they belong to fewer phylletic trunks than formerly believed, but that the trunks consisting exclusively of primary freshwater fishes are larger. The freshwater Teleosts of the primary division are less offsprings of repeated marine colonizations and more branches of taxa inhabiting the fresh waters since the Mesozoic.

Also the primary marine groups of Teleosts with many representatives in fresh waters belong, according to the new classification, to fewer but larger phylletical trunks. The most important is the Atheriniformes one, consisting in Exocoetoidei (chiefly marine, but the Hemirhamphidae with many genera and species in fresh water), Cyprinodontoidei (8 families, all belonging to the secondary division of freshwater fishes) and Atherinoidei (Melanotaeniidae — apparently primary division —, Atherinidae, marine but with very many freshwater derivatives, then Neostethidae and Phallostethidae — salt tolerant but occurring mainly in fresh and brackish waters). Other higher taxa with many freshwater representatives are the Symbranchiformes (mostly in fresh waters but salt-tolerant), the Salmonoidei (mainly diadromous), the already mentioned Galaxioidei and even the Percoidei (most families marine, but three belonging to the primary division of freshwater fishes, one — the speciose Cichlidae — to the secondary division, then the Gadopsidae restricted to Australian fresh waters and many genera of exclusively freshwater species within other families, such as Serranidae, Kuhliidae, Cetropomidae, etc).

Darlington [6] groups the families of the primary division freshwater Teleosts in Ostariophysii and non-Ostariophysii. This is not only a practical classification — the number of species within the Ostariophysii surpassing that of all other families of the division — but corresponds to two stages in the colonization of land masses by freshwater fishes. The dispersal of non-Ostariophysii — especially of Osteoglossomorpha, but also of Percopsiformes, Nandidae, Percidae, perhaps of Esocoidei, then on non-Teleosts such as Polypteriformes, Amiidae and Dipnoi — is older than that of Ostariophysii. This is rather curious, the Ostariophysii having several archaic characters. According to their morphology, the Ostariophysii appear more primitive (and thus older) than Perciformes; yet Zoogeography indicates that the dispersal of Percidae and Nandidae is older than that of Cyprinoidei. Probably the Ostariophysii are as old as the other main groups of Teleosts, but spread over large land masses and became dominant in a more recent geological period. The main centers of differentiation and radial distribution of Ostariophysii were South America for Characoidei and Siluriformes and South-East Asia for Cyprinoidei and other families of Siluriformes. From South-East Asia, the Cyprinoidei spread over whole Eurasia. Africa has rather few Characoidei and Siluriformes and the Cyprinidae reached it only recently; North America has a single family of Siluriformes and fewer and more recent Cyprinoidei. The relative paucity of Ostariophysii in these two continents explains why both retained more representatives of non-Ostariophysian families, especially primitive ones such as Osteoglossomorpha, Percopsiformes, Kneriidae and Phractolaemidae (or non-Teleosts: Polypteridae, Amiidae) than South America and Eurasia.

Continental drift is at present the best explanation of the distribution of Osteoglossomorpha, Ostariophysii, Nandidae and Percidae. It is significant that two brilliant zoogeographers — Darlington [7] and Myers [13] — formerly opponents of drift, recently accepted it. I think the greatest difficulty in explaining the dispersal of Ostariophysii by continental drift is the great distance between the probable center of evolution and radial distribution of the two "sister groups": the Characoidei (South America) and the Cyprinoidei (South East Asia). Accepting geographic isolation as the most frequent, or even the only mechanism of speciation in higher animals, I consider the original ranges of two sister groups were not the same, but neither so distant; on the contrary, they were very close. In spite of this difficulty, the theory of continental drift explains better the distribution of Ostariophysii than that of land bridges or of the stability of oceans and continents.

*

Although this paper deals with the Teleosts, I make a remark on the only freshwater family of Elasmobranchii: the Potamotrygonidae. Up to now, the Potamotrygonidae were considered restricted to South America and Darlington ascribed them to the peripheral freshwater fishes. Yet Stauch and Blanc [15] described a species from West African fresh waters and a fossil species was recorded from Lake Rudolph in East Africa. The family has thus the same distribution as the Characoidei, Lepidosirenidae, etc. and may belong to the primary division freshwater fishes or, at least, have the same age in fresh waters as the primary division

families, especially when one considers that the Elasmobranchii are much older than the Teleosts.

★

The distribution of subfamilies within large families too has a zoogeographic significance and I shall discuss the distribution of subfamilies, according to most recent revisions, within the three largest families of primary division freshwater Teleosts from the Northern Hemisphere.

Percidae. Collette [5] divides the Percidae in two subfamilies, the more primitive of which, Percinae, consists of two tribes: a less specialized one, Percini, with 3 genera: one Holarctic, two European (partially Eurosiberian) and a more specialized one, Etheostomatini, with 3 genera and more than 100 species in Eastern North America. The second subfamily, Luciopercinae, consists of a less specialized Holarctic genus, *Stizostedion*, and two specialized ones in Central and South Europe. Europe has thus more basic groups of Percidae than North America, but North America much more species; the family may have originated in Europe.

Cyprinidae. There is no recent successful tentative to give a world-wide classification of this very speciose family; but in several faunistic works there are more or less concordant subdivisions of the Cyprinidae in subfamilies. According to these regional tentatives and to my own experience in Cyprinidae, the following 10 subfamilies can be provisionally accepted:

Danioinae (= Bariliinae, Rasborinae): one of the less evident subfamily, perhaps not monophyletic, but containing several of the apparently most primitive genera within the family. It extends from South China to Africa. One genus, *Barilius* occurs almost within the whole range of the subfamily; some 14 genera live in East Asia (Amur drainage and Japan to South China and North Vietnam), some of these genera are rather highly specialized and their inclusion in the subfamily is arbitrary; 14 other genera live in South Asia, some of them reaching South China but not the Yangtze (from the many genera occurring in Indo-China only two reach Indonesia, and one, *Nematabramis*, is restricted to Borneo and the Philippines); 3 are restricted to Africa.

Leuciscinae (including the Abramidinae, Medinae, Pimephalinae, etc.): apparently monophyletic, but morphologically hardly distinct from the Danioinae, the Leuciscinae are a Holarctic subfamily. Two genera (*Leuciscus* and *Phoxinus*) are Holarctic but the first is represented by distinct subgenera in North Eurasia, eastern and western North America. 26 genera are Palaearctic: 3 East Asian, 2 Eurosiberian, 11 European (most of them fossil also in Siberia), 5 South European, 3 West Asian, 1 West Mongolian, 1 West Mongolian and Anatolian. 37 genera are North-American, 17 living in the eastern part of the continent (many of them being speciose, *Notropis* has some 100 species), 18 (many monotypic) in the Pacific drainage. The American genera are more primitive and much closer to one another than the Eurasian; the North American fauna of Leuciscinae is, like that of Percidae, richer but less diversified than the Palaearctic. Each West American genus lives in a single river drainage; this indicates that each western river received its fauna independently from the East.

Cultrinae: apparently a natural subfamily, consisting of 21 genera (Bănărescu [2]): 11 live in East Asia (Amur to Central Vietnam), 9 in South Asia (none of them reaching China, North or Central Vietnam), one — *Pelecus* — in Europe; curiously enough, this genus is closer to the South Asian than to the East Asian genera.

Xenocyprininae: a natural subfamily, closer to Cultrinae: 2 genera, some 10 species in East Asia.

Acheilognathinae (=Rhodeinae): a very natural subfamily, consisting of some 5 to 7 genera, all in East Asia (southwards to North Thailand), but one subspecies in Europe, which it reached over Siberia.

Gobioinae: a natural subfamily, consisting of 18 genera, all East Asian (Bănărescu and Nalbant [3]), one of them also in Siberia, Europe and Anatolia.

Barbinae (including the Labeoninae and Garrinae): the richest subfamily, consisting of more than 60 genera and many hundreds of species; its range includes Eurasia (except Siberia) and Africa. The largest number of genera occur in Indo-China, many but not all of them reaching India and/or Indonesia, a few southern China, one (*Cyclocheilichthys*, apparently lacking in India) was recently recorded from Anatolia. Some genera are restricted to southern East Asia (Yangtze to North Vietnam), only one of them reaching the Amur and Japan; some genera are endemic to lake Lanao in the Philippines. The West Asian genera are in general distinct from the South Asian; one West Asian genus, *Barbus* s. str. reaches Europe and one genus, *Aulopyge*, is restricted to South-East Europe. The more than 300 African species belong to only 4 large genera: the West Asian *Varicorhinus*, the South Asian *Labeo*, the West and South Asian *Garra*, then *Barbus* s. lato (which links the West-Asian *Barbus* s. str. and the South Asian *Tor* and *Puntius*), besides the monotypic, apparently primitive *Oreodaimon* and some cave-dwelling genera related to *Barbus*. The Barbin fauna of Africa is thus richer but less differentiated than the Eurasian, like the North American fauna of Percidae and Leuciscinae.

Cyprininae, hardly distinct from the Barbinae: some 4 genera in East Asia, one species reaching Europe and another is Eurosiberian.

Schizothoracinae: apparently derived from the Barbinae, consisting of some 12 genera: 11 most High Asian, one species in Anatolia and one monotypic genus in South India.

Hypoptalmichthyinae: 2 highly specialized genera in East Asia.

Cobitidae. This family consists of 3 very well-delimited and natural subfamilies (Nalbant [14]):

Botiinae: 2 genera, one (*Botia*) in South Asia northwards to Yangtze, the second, *Leptobotia*, in East Asia, northwards to Japan and Amur drainage (Nalbant [14]).

Cobitinae: 15 genera: 9 South-Asian, 3 East-Asian (all monotypic), 2 Palaearctic. 1 East-European (Nalbant [14]; Bănărescu and Nalbant, under press).

Noemacheilinae: more than hundred species, at present most of them ascribed to one genus, *Noemacheilus*. According to unpublished data (Bănărescu and Nalbant) there are actually several genera, most of them restricted to South Asia (northward to Hainan and Yunnan); the largest one, *Schistura*, reached West Asia where there are also some

endemic genera. The East Asian *Orthrias* spread over Siberia to Europe and West Asia. The few but speciose and highly specialized High Asian genera are apparently derivatives of *Orthrias*.

The main zoogeographic conclusions of this reviewing of the distribution of the subfamilies of carps and loaches are :

1. South and East Asia were the main centers of differentiation and dispersal of both families. The single Holarctic subfamily, the Leuciscinae, dispersed probably from Siberia which had, up to the Pliocen, a richer fauna than now.

2. The Cyprinoidei faunas of South and East Asia are related, but distinct. There are 5 East Asian subfamilies of carps which do not reach or reach only tangentially South Asia ; the subfamilies they bear in common are usually represented by distinct genera in South Asia and East Asia.

3. The Cyprinoidei fauna of East Asia is closer to the South Asian (Oriental) than to the Holarctic. Within the few elements which are common to East Asia and the Holarctic, one can easily distinguish Holarctic immigrants in East Asia (3 monotypic genera of Leuciscinae : *Pseudaspius*, *Ctenopharyngodon*, *Mylopharyngodon*) and East Asian immigrants in Europe (*Gobio*, *Rhodeus*, *Cyprinus*, *Carassius*, *Cobitis*, *Misgurnus*, the ancestors of *Sabanejewia*), none of which reached North America. The distribution of other families (Holarctic Percidae in Europe, Oriental Siluroidei, Mastacembelidae, etc. in East Asia) supports this conclusion (see also Bănărescu [1]).

4. The High Asian fish fauna is a mixture of South Asian and East Asian derivatives.

REFERENCES

1. BĂNĂRESCU P., Arch. Hydrobiol., 1960, **57**, 16—134.
2. — , Rev. Roum. Biol., Zool., 1967, **12**, 5.
3. BĂNĂRESCU P., NALBANT, T., Rev. Roum. Biol., Zool., 1965, **10**, 4, 219—229.
4. БЕРТ Л. С., *Система Рыб*. Труд. Зоол. Инст. Акад. наук, 1940, **5**, 2, 87-517.
5. COLLETTE B. B., Copeia, 1963, **4**, 615—623.
6. DARLINGTON Ph. Jr., *Zoogeography*, J. Wiley and Sons, New York, 1957.
7. — , *Biogeography of the Southern End of the World*, Harvard University Press, Cambridge, Massachusetts, 1965.
8. GREENWOOD P. H., ROSEN D. E., WEITZMAN S. H., MYERS G. S., *Phyletic Studies of Teleostean Fishes with a Provisional Classification of Recent Forms*. Bull. Amer. Mus. Nat. Hist., 1966, **131**, 4, 339—456.
9. Mc DOWALL R. M., Tuatara (J Biol. Soc. Victoria Univ.), 1964, **12**, 59—67.
10. MILLER R., R., Copeia, 1966, **4**, 773—802.
11. MYERS G. S., *Freshwater Fishes and West Indian Zoogeography*, Ann. Rep. Smith. Inst. for 1937, 1938, 339—364.
12. — , Stanford Ichthyol. Bull., 1951, **4**, 11—21.
13. — , Copeia, 1966, **4**, 766—773.
14. NALBANT T., Trav. Mus. Hist. Nat. "Gr. Antipa", 1963, **4**, 343—379.
15. STAUCH A., BLANC M., Bull. Mus. Hist. Nat. Paris, 1962, **34**, 166—171.
16. STOKELL G., *The Distribution of the Family Galaxiidae*. Proc. 7th Pacif. Sci. Congr., 1953, **4**, 48—52.

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COMPARATIVE BIOMETRICAL DATA OF *MYTILUS GALLOPROVINCIALIS* LAM. FROM THE SHORE AND THE DEEP OF THE BLACK SEA

BY

M. T. GOMOIU

The values of characteristic parameters are given for the first time for the bivalve *Mytilus galloprovincialis* Lam. from the Black Sea on the basis of biometrical measurements and mathematical interpretation. Two *Mytilus* populations are recorded according to biotopes; the shore population — including the robust specimens with very thick shells (45.45% of their total weight) covered with thick epibiosis — and the deep sea population from the silty areas, including the suppler specimens with thin shells (36.24% of total weight) and mostly devoid of epibiosis. In conclusion it is stated that the shore *Mytilus* from the Black Sea is more resemblant to *Mytilus* from the Mediterranean Sea. It is suggested that the volume of individuals be included among the biometrical measurements.

INTRODUCTION

The taxonomy of *Mytilus galloprovincialis* Lam., a species occurring in most European seas, is still controverted in many of its features [8], [9], [11], [12], [16].

Although numerous papers were devoted to the distribution and to various aspects of the biology of the Black Sea mussel [1—6], [10], [13—15], [19—23], [27—29], literature is scarce with regard to its systematics.

Milashevich [17] states, and other workers agree with him [7], [11] that *Mytilus galloprovincialis* Lam. from the Black Sea is an extremely variable species, and that no identical specimens can be found. At the same time another remark has been made, which I think rather inaccurate, viz. that no certain direction of the variability of *Mytilus* can be established, conducive to determining a constancy or particularity induced by its living conditions.

The papers on systematics [7], [11], [17], dealing with specific variability usually give descriptions of the variations in shape and coloration but no biometrical measurements, thus neglecting the quantitative data of the directions of variation.

Our biometrical measurements have shown that within the variability of *Mytilus* from the Black Sea, which is so definite that "finding two identical specimens seems an impossibility", there exist rules that differentiate the shore mussel from those of the deep sea area depending on their different adaptation to the environment.

MATERIAL AND METHOD

Two *Mytilus* lots were analyzed. One lot represented a population from the rocky shore area (marked as "S") and included 60 specimens. These mussels were collected by the author by diving at 5 m depth on September 1, 1965 in the Constanța area. The second lot (marked as "D") consisted of 124 specimens and represented a population collected on August 8, 1965 from the mussel area at 35 m depth.

All linear measurements and weights as well as the mean values of the measurements are listed in Table 1.

In interpreting the results I used the indices and parameters generally employed in mollusk biometry [8], [9], [24]. Also, by the mathematical-statistical interpretation of actual data, I tried to find new elements capable of better outlining the results.

DISCUSSION

In the following comparative interpretations of the shore and deep sea mussels, the length of the shell is chosen as original reference term.

By size categories, the mean length values of the analyzed specimens were similar in both populations. The values of the other dimensions were, however highly variable (Table 1).

Table 1

Mean values of the biometrical measurements of the shore (S) and deep sea (D) mussels from the Black Sea, by size categories

	SIZE CATEGORIES											
	+ 3cm		+ 4cm		+ 5cm		+ 6cm		+ 7cm		+ 8cm	
	S	D	S	D	S	D	S	D	S	D	S	D
L	3.69	3.35	4.65	4.67	5.47	5.31	6.47	6.50	7.54	7.25	8.34	8.27
I	2.17	1.84	2.73	2.52	3.08	2.66	3.49	3.25	3.75	3.47	4.23	3.95
h	1.39	1.23	1.82	1.72	2.14	1.80	2.46	2.26	2.88	2.51	3.28	2.75
wTe	5.82	3.93	12.01	9.70	18.30	13.00	33.28	23.97	50.07	29.34	72.18	47.20
wT	5.70	3.93	10.89	9.70	17.01	13.00	29.12	23.97	42.38	29.34	61.60	47.20
ws	2.35	1.52	4.89	3.44	7.87	4.49	14.16	8.51	20.22	9.98	27.10	18.52
wc	0.88	0.48	1.66	1.34	2.32	1.96	3.85	4.21	5.64	5.39	8.63	9.32
ww	2.47	1.93	4.34	4.92	6.82	6.55	11.23	11.25	16.52	13.97	25.87	19.36
wdc	0.17	0.08	0.28	0.20	0.36	0.31	0.53	0.63	0.80	0.79	1.26	1.41
L/I	1.70	1.82	1.70	1.85	1.78	1.83	1.86	2.00	2.01	2.09	1.97	2.09
L/h	2.65	2.73	2.56	2.72	2.57	2.72	2.63	2.88	2.63	2.90	2.55	3.01

L = length
I = height
h = thickness

wTe = total weight
wT = body weight without epibiosis
ws = shell weight

wc = weight of wet meat
ww = weight of water between valves
wdc = weight of meat dried at 105°C

The values characteristic of each mussel population analyzed (Table 2) were found by totalling the three dimensions and referring each of them to the total considered as 100.

Table 2

Rates of three dimensions and correlation coefficients in the analyzed mussels and in some populations from the Mediterranean Sea

	Black Sea		Mediterranean Sea		
	Shore	Deep sea	Venice lagoon	Ganzirri lake	Tunisian coasts
L	51.75	53.85	52.57	52.02	52.38
I	28.29	27.30	27.45	27.41	27.74
h	19.96	18.85	19.98	20.57	19.87
	100.00	100.00	100.00	100.00	99.99

$I = L \times 0.547$ $I = L \times 0.507$ $I = L \times 0.522$ $I = L \times 0.527$ $I = L \times 0.529$
 $h = L \times 0.374$ $h = L \times 0.350$ $h = L \times 0.380$ $h = L \times 0.395$ $h = L \times 0.379$

Referred to other dimensions, the length of the deep sea mussel has higher values than that in the shore population. The ratio of the three dimensions points to a more robust shore mussel and to a more supple deep sea one.

On comparing our data with data published on *Mytilus* from the Mediterranean [8], [9], [24] (Table 2) the following remarks can be made:

— the values of the length in the Black Sea mussels are extreme ones as compared to those of specimens from the Mediterranean; minimum values were recorded in the shore mussels, maximum ones in the deep sea specimens;

— the values of the height in the Pontic specimens are extreme ones as compared to those in the Mediterranean specimens, but the minimum values were recorded in the deep sea mussels and the maximum values in the shore specimens.

— Black Sea mussels are as thick as or slightly less thick than those from the Mediterranean sea.

It may be concluded that adaptation of the Black Sea mussel evolved in two directions. Nevertheless, the Pontic shore mussel is more similar to and has more affinities with *Mytilus* from the Mediterranean.

The coefficients obtained from the ratios of the height and thickness to the length clearly showed the difference between the two Black Sea populations (Table 2); the values of the coefficients in the shore mussel are higher than in the deep sea specimens. The values of the height coefficients are average ones in the Mediterranean mussels [8], [9], [24] as compared with those from the Black Sea. The thickness coefficients are higher in the Mediterranean mussels compared with those from the Black Sea.

The values of length-to-height (L/I) and length-to-thickness (L/h) ratios are higher in the deep sea specimens, pointing out once more the difference between the two populations (Table 3).

Table 3
Ratios of length to remaining dimensions and their correlation coefficients
in the Pontic mussels

	L/I	L/h	r-L/I	r-L/h
Shore mussels	1.84	2.60	0.94	0.94
Deep sea mussels	1.95	2.83	0.93	0.92

The difference between the minimum and maximum values of the length-to-other-dimensions ratio is a high one, showing a large range of variability of the specimens ($L/I = 1.62 - 2.11$ in the shore mussel and $1.72 - 2.35$ in the deep sea mussel; $L/h = 2.20 - 2.90$ in the shore mussel and $2.34 - 3.18$ in the deep sea mussel).

Within each population from the Black Sea a good correlation was found between length and the other two dimensions (Table 3), the correlation coefficients (r) having in all instances values approximating 1.

As compared to Genovese's data [9] for the Mediterranean mussel, our values are higher; however, the shore mussel of the Black Sea is closer to the Mediterranean one and even to Lamarck's type specimen of *Mytilus galloprovincialis* in which the L/I ratio is 1.82.

And now let us analyse weight relations.

The total weight of the shore mussel is increased by 11.5% by its heavy epibiosis, mostly *Balanus* (the weight of the epibiosis ranges between 2 per cent — in the small specimens — and 20% — in the large ones — of the total body weight). In the Mediterranean, the worse enemy of Mussel breeding are also species of the genus *Balanus* [25]. The deep sea mussels are generally free of epibiosis, being less used by other organisms as a substrate.

Based on the total weight of the mussel (after removal of the epibiosis) considered as 100, the rates of the shell, meat, and water found between the valves are as follows:

— the weight of the shell is higher in the shore mussel (45.45%) than in the deep sea mussel (36.24%);

— the wet meat is heavier in the deep sea mussel (16.13%) than in the shore mussel (14.12%);

— the weight of the water between the valves is higher in the deep sea specimens (47.63%) than in the shore ones (40.43%);

— the meat dried at 105°C yields a higher rate from the wet meat in the shore mussel (16.10%) than the deep sea mussel (15.36%).

All the above ponderal relations are accounted for by the different adaptation of the two populations of Black Sea *Mytilus*.

The shore mussels live in a rather agitated area, but with good supplies of food and oxygen. Adaptation resulted in this case in a thicker, better resisting shell, with strong adductive muscles and much bissus.

The deep sea mussel lives in quiet areas; its living conditions are more constant, its food supply less abundant.

As *Mytilus* has an allometric growth, we shall try to find correlation parameters between the length and the weight of the mussels.

The relation between length and weight, similarly as that between any part and the whole body of the animal [30] is given by the equation:

$$w = k \times l^n$$

in which w = weight, l = length, and k and n are constant.

Introducing in this general equation the actual values one obtains the correlation parameters between the weight and the length for each of the Black Sea populations (Table 4). In view of a better computation and

Table 4
Values of length-weight relations for the mussels of the Black Sea

	Shore mussel	Deep sea mussel
Total weight	$2.08 \times 10^{-4} \times l^{2.84}$	$2.66 \times 10^{-4} \times l^{2.73}$
Shell weight	$0.32 \times 10^{-4} \times l^{3.11}$	$2.16 \times 10^{-4} \times l^{2.53}$
Meat weight	$0.799 \times 10^{-4} \times l^{2.59}$	$0.014 \times 10^{-4} \times l^{3.53}$
Water weight	$5.40 \times 10^{-4} \times l^{2.38}$	$1.84 \times 10^{-4} \times l^{2.64}$

a more precise determination of the mean values we shall operate on the bilogarithmic diagram of the relation length-weight (Figs. 1 and 2).

A few conclusions may be drawn from the analysis of the parameters obtained (Table 4).

1. It is generally observed that the weight depends on approximately the cube of the length, which might involve a value of a volume unit (or at least comparable to a volume). In this instance k may be treated as the density, since $w = \rho V$.

2. The weight of the shore mussel shell is more length-dependent than that of the deep sea specimen.

3. The weight of the meat in the deep sea mussel is more length-dependent than that in the shore mussel.

From the parameters obtained for the weight of the mussels or their component weights, the dependence of densities to the volumes may further be deducted. It should be stressed that in such instances we are not dealing with actual densities and/or volumes, but with apparent, fictitious ones deduced from formulas which can very well be assimilated with the real ones. We are further continuing to deal with volumes instead of lengths (Table 5).

Introducing volume values (Table 5) in the equation of density

$$\rho = \frac{w}{V}$$

one obtains the values of the densities of the various component parts of the mussels (Table 6).

From the comparative analysis of the computed densities the following conclusions may be drawn:

1. Densities decrease with growing volumes in both populations. With a growing of the volume by 1%, the density of the shore mussel

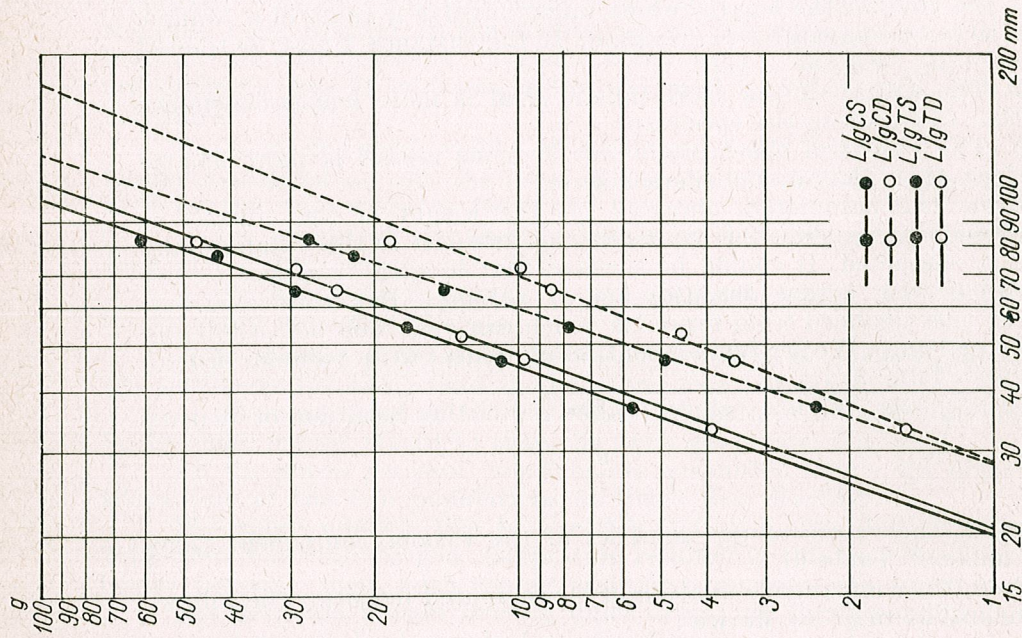


Fig. 1. — Length-total weight relations (L/gT) and length-shell weight relations (L/gC) in *Mytilus galloprovincialis* from the Romanian Black Sea shore: L/gTS and L/gCS for shore populations; L/gTD and L/gCD for

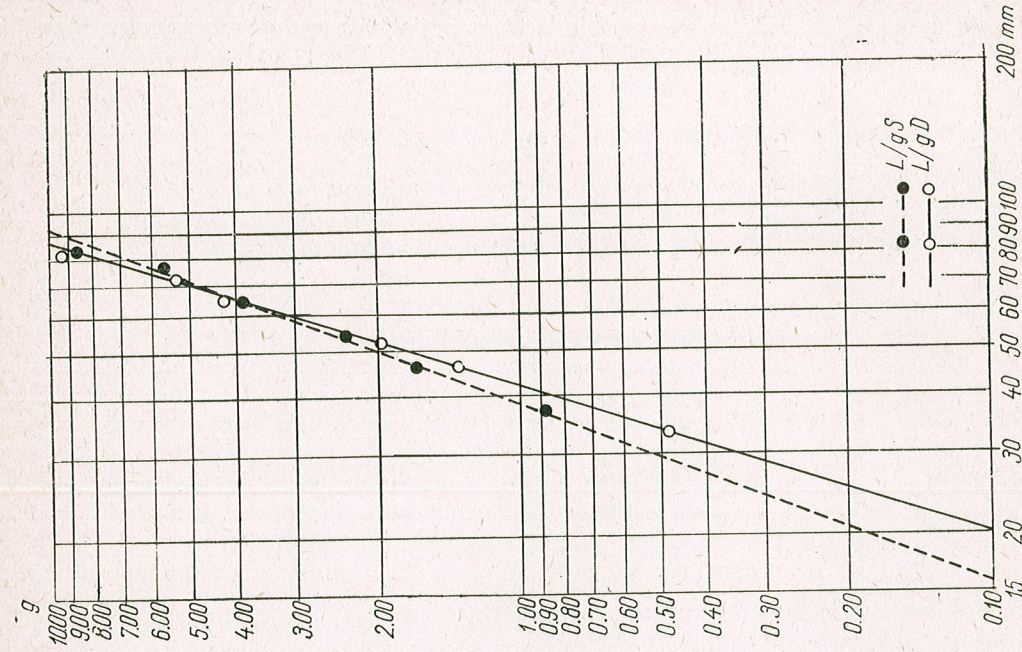


Fig. 2. — Length-weight of soft part relations in *Mytilus galloprovincialis* from the Black Sea: L/gS for shore populations; L/gD for deep sea populations.

Table 5

Values of the relations length-weight for mussels from the Black Sea computed in volumes (instead of lengths)

	Shore mussel	Deep sea mussel
Total weight	$2.08 \times 10^{-4} \times V \times V \frac{0.16}{3}$	$2.66 \times 10^{-4} \times V \times V \frac{9.27}{3}$
Shell weight	$0.32 \times 10^{-4} \times V \times V \frac{0.11}{3}$	$2.16 \times 10^{-4} \times V \times V \frac{0.47}{3}$
Meat weight	$0.799 \times 10^{-4} \times V \times V \frac{0.41}{3}$	$0.014 \times 10^{-4} \times V \times V \frac{0.53}{3}$

decreases by 0.05% while in the deep sea mussel the decrease is some 18 times as high, i.e. 9%.

2. With growing volumes in the shore mussel, the densities of the shells increase while in the deep sea shells they decrease. Thus with an increase in the volume of the shore mussel by 1%, the density of its shell increases by 0.04%; with an increase in the volume of the deep sea mussel by 1%, the density of its shell decreases by 0.16%.

3. With growing volumes in the shore mussel, the density of the meat decreases, while in the deep sea mussel density increases.

Thus, with 1% growing of the volume in the shore mussel, meat density decreases by 0.12%, while with a similar growing of the volume in the deep sea mussel, density increases by 0.18%.

The above conclusions all show the distinct particularities of the two populations of Black Sea mussels. Also, density relations point to the fact that biometrical measurements should include — in addition to length — the volume, which is more closely related to the weight than other parameters are (and, after all, it is easier and more accurate, if not more logical, to measure the volume of the mussel rather than its other parameters).

Although the parameters obtained clearly define the occurrence of two well differentiated mussel populations in the Black Sea, one should

Table 6

Values of apparent (computed) densities of various component parts in the mussels from the Black Sea

	Shore mussel	Deep sea mussel
Whole mussel	$\frac{2.08 \times 10^{-4}}{V^{0.05}}$	$\frac{2.66 \times 10^{-4}}{V^{0.9}}$
Shell	$0.32 \times 10^{-4} \times V^{0.04}$	$\frac{2.16 \times 10^{-4}}{V^{0.16}}$
Meat	$\frac{0.799 \times 10^{-4}}{V^{0.12}}$	$0.014 \times 10^{-4} \times V^{0.18}$

not jump to systematic conclusions that should lead to building subspecific taxa. It may be emphasized that both populations belong in a single species, *Mytilus galloprovincialis*. This species has a great plasticity and a large variability tending to ecological differentiation.

In addition to further biometrical studies which should be conducted in all areas of distribution, using the same methods, physiological, biochemical, histological and other studies are necessary before the systematics of *Mytilus galloprovincialis* Lam. is fully understood.

REFERENCES

1. ANTIPA GR., *Studii asupra Pescăriilor din România*, Impr. Statului, Bucharest, 1895.
2. — *Pescăria și pescuitul în România*, Bucharest, 1916.
3. BACALBAȘA-DOBROVICI N., *Lucr. științ. Staț. Zool. "Prof. Ioan Borcea"*, Agigea, 1959.
4. BĂCESCU M., *Hidrobiologia*, 1961, **3**, 17—46.
5. BORCEA I., *Ann. Sc. Univ. Jassy*, 1926, **14**, 129—239.
6. — *Ann. Sc. Univ. Jassy*, 1931, **16**, 655—750.
7. ДРАГОЛИ А. П., *Распределение бентоса и биология донных животных в южных морях*, 1966, Киев, 3—15.
8. GENOVESE S., *Rapp. Proc. verb. réunions, C.I.E.S.M.M.*, 1961, **16**, 3, 799—809.
9. — *Boll. Zool. U.Z.I.*, 1965, **32**, 2, 247—262.
10. GOMOIU M. T., *Courr. Ind. Scient.*, 1965, **80**, 16.
11. GROSSU AL. V., *Fauna R. P. R.*, Ed. Acad. R. P. R., 1962, **3**, 3.
12. HEPPEL B. T., *J. mar. biol. Ass. U.K.*, 1957, **36**, 33—40.
13. JITARIU M., PORA E. A., WITTEMBERGER C., *Anal. Acad. R. P. R., Seria A*, 1949, **2**, Mem. 13.
14. КАНЕВА-АБАДЖИЕВА В., МАРИНОВ Т., *Тр. Центр. науч. — исслед. инст. рыб и рыболов Варна*, 1960, **3**, 117—161.
15. КАНЕВА-АБАДЖИЕВА В., *Изв. Центр. научн.-исслед. инст. рыб и рыболов Варна*, 1962, **2**, 67—79.
16. MARS P., *Vie et Milieu*, 1966, *Suppl.*, 20.
17. МИЛАШЕВИЧ, К. О., *Фауна России и сопредельных стран*, Петроград, 1916, **1**.
18. МИРОНОВ Г. Н., *Тр. Севастопол. Биол. Ст.*, 1948, **6**.
19. НИКИТИН В. Н., *Устрицы, мидии и креветки как объект промысла в Черном и Азовском морях*. Рыбное хоз. СССР, М., 1933, **3**, 17—21.
20. — *Доклад Акад. Н. СССР*, 1958, **120**, 4, 893—895.
21. — *Доклад Акад. Н. СССР*, 1960, **130**, 3, 124—125.
22. POPONICI Z., *Anal. Inst. Cerc. Pisc. Rom.*, 1942, **1**, 187—190.
23. PORUMB FL., ANDRIESCU I., *An. St. Univ. "Al. I. Cuza"*, Iași, Sect. II, 1964, **10**, 1, 93—100.
24. RICCI E., *Ann. St. Océan. Salambô*, 1957, **11**.
25. SACHNI C. F., RENZONI A., *Pubbli. Staz. Zool. Napoli*, 1962, **32** suppl.
26. САЛЬСКИЙ, В. О., *Видав. Акад. Н. Украин. ССР*, 1958.
27. СЛАВИНА О. Я., *Рост мидии в Севастопольской бухте. Бентос*, Сер. Биология моря, Акад. Н. Украин. ССР, Киев, 24—29, 1965.
28. ВИНОГРАДОВА З. А., *Тр. Карадаг, Биол. Ст.*, 1950, **9**, 100—158.
29. ВОРОБЬЕВ В. П., *Труды АЗЧЕРНИРО*, 1938, **11**.
30. WILBUR K.M., OWEN G., *Growth. Physiology of Mollusca*, Academic Press, New York, London, 1964, 211—242.

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AMMONIA TEPIDA (CUSHMAN) (ORD. FORAMINIFERA).
SOME FEATURES OF ITS VARIABILITY IN THE
BLACK SEA BASIN

BY

M. TUFESCU

Ammonia tepida (Cushman) was first identified to occur in the Black Sea basin, viz. in lake Sinoe. Biometrical data were used for comparison with the type species of the genus *Ammonia beccarii* (L.). Salinity variability was found to be an essential factor for this form in the Black Sea basin. Abnormal tests of *Ammonia tepida* are described for the first time.

While working on a foraminiferal sample from lake Sinoe¹ I was shocked by the mass occurrence of a species never before mentioned from the Black Sea basin [7—9]. This was *Ammonia tepida* (Cushman) Bandy 1961, first described in 1926 as a variety of *Ammonia beccarii* (L.) by J. A. Cushman from the Caribbean Sea (Puerto Rico). It was later found also in the Gulf of Mexico and northwards on the Atlantic shore from Florida to north of New York in Martha's Vineyard Island; on the Californian coast, on the Brazilian coast as well as on the European coast (south of Portugal) and in the south Baltic Sea on Poland's coasts [4]. The species was not cited as such from the eastern Mediterranean, however, its occurrence there might be assumed² since none of the varieties derived from *Ammonia beccarii* (L.) were analysed separately; they were dealt with collectively under the name of the genotype — *Ammonia beccarii* (L.) [10].

¹ The material was kindly made available for me by Dr. M. Băcescu, to whom I wish to express my grateful thanks. I am also thankful to Professor Dr. N. Botnariuc who is tutor for my research and whose advice has always been invaluable to me.

² In some material from the collection of Dr. R. A. Brandt's expedition kindly put at my disposal by Professor Al. Grossu, I found two *Ammonia tepida* (Cushman) specimens from Bengasi (African shore of the Mediterranean).

It should be mentioned that many authors still consider *Amm. tepida* as a "variety" of *Amm. beccarii* (L.), though their tests are essentially different. One formal argument pleading in favour of subordinating *Amm. tepida* (Cushman) to *Amm. beccarii* (L.) results from the comparison of the histograms of the distribution of the prolocular diameter in the two species (Fig. 2). It was observed that values in *Amm. tepida* (Cushman) from lake Sinoe were contained in those found for *Amm. beccarii* (L.) off Rimini (examined by R. Cifelli [5] from the locality of description of the holotype), but the arithmetical ponderal mean $\bar{X}_{Amm. tepida} = 74 \mu$ is moved with a variation class toward higher values ($\bar{X}_{Amm. beccarii} = 66 \mu$). Yet, the character differences between the two species as well as the areal sympatricity plead against subordinating — as I stated above — *Amm. tepida* (CUSHMAN) to *Amm. beccarii* (L.).

★

The sample from lake Sinoe was taken on 28 June 1964, at 0.20 m depth, water salinity being 19.9‰. It included:

— <i>Amm. tepida</i> (Cushman)	141 individuals	= 42 per cent of total number
megalospheric forms	125 individuals	= 88.5 per cent
microspheric forms	1 individual	= 0.9 per cent
abnormal forms . . .	15 individuals	= 10.6 per cent
	141 individuals	= 100 per cent
— <i>Nonion</i> sp.	190 individuals	= 56 per cent of total number
normal forms . . .	187 individuals	= 98 per cent
abnormal forms . . .	3 "	= 2 per cent
	190 "	100 per cent
— <i>Elphidium</i> sp.	5 individuals	= 2 per cent of total number

The present material of *Amm. tepida* (Cushman) (Fig. 1) presents the following means: diameter of the proloculum 74μ (in several forms this diameter ranges between 50 and 110μ) (Fig. 2); maximal diameter $D = 0.345$ mm, minimal diameter $d = 0.294$ mm (Fig. 5). Two specimens recorded from the south Baltic Sea [4] have $D = 0.33$ mm and 0.36 mm respectively, thus showing values similar to those in the specimens from lake Sinoe.

I found *Amm. tepida* (Cushman) in samples from the Black Sea as well. The specimens more strongly convex dorsally, with chambers more prolonged in the coiled direction, cited by Dolgopolskaja and Pauli

Fig. 1. — Two *Ammonia tepida* (Cushman) specimens from lake Sinoe: a = dorsal view; b = ventral view.

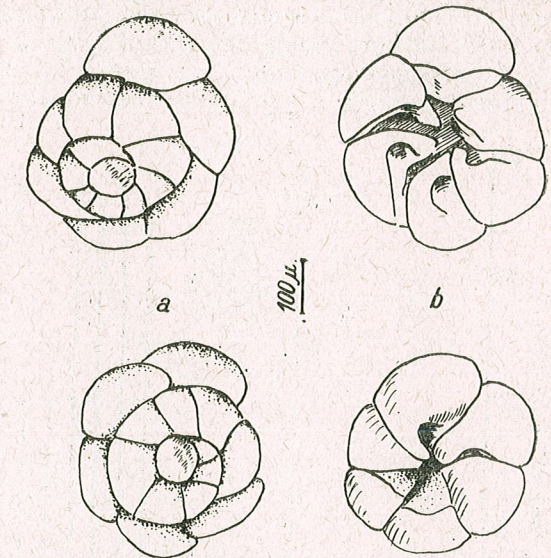
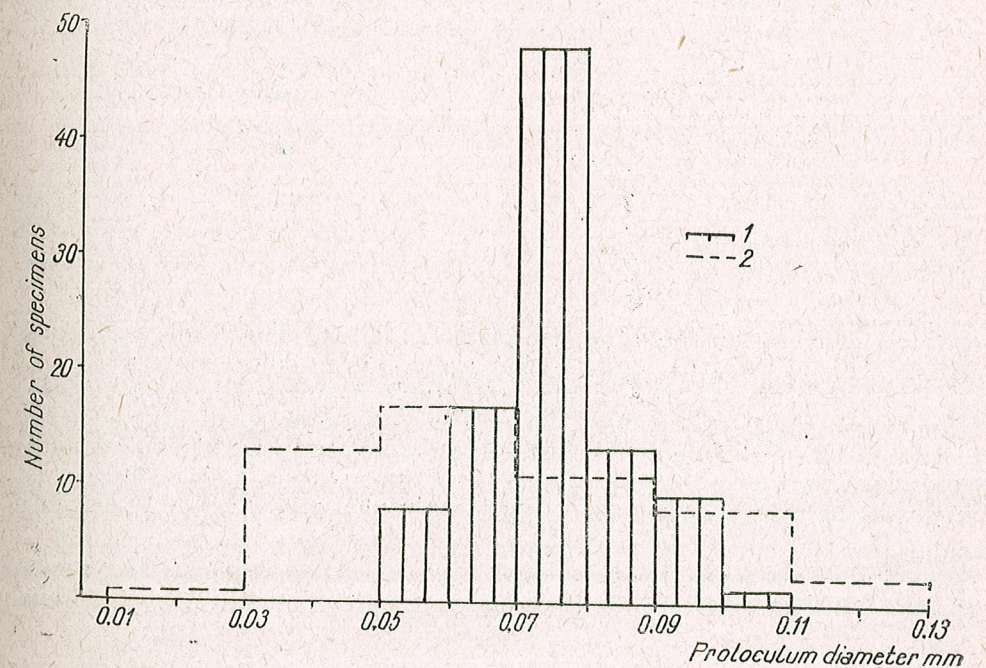


Fig. 2. — Histogram of prolocular diameter in *Ammonia tepida* (Cushman) from lake Sinoe (1) and comparative one for *Amm. beccarii* (L.) off Rimini (2).



[8] as belonging to *Rotalia beccarii* (L.) and especially to *Discorbis vilardeboana* (D'Orb.) var. *karadagica* Dolg. and Pauli as well as the forms recorded by later authors from the Black Sea as *Rotalia* = *Ammonia beccarii* (L.) var. *karadagica* Dolg. and Pauli [7], [9] also belong to that species. Umbilical material is usually lacking, however, specimens having umbilical

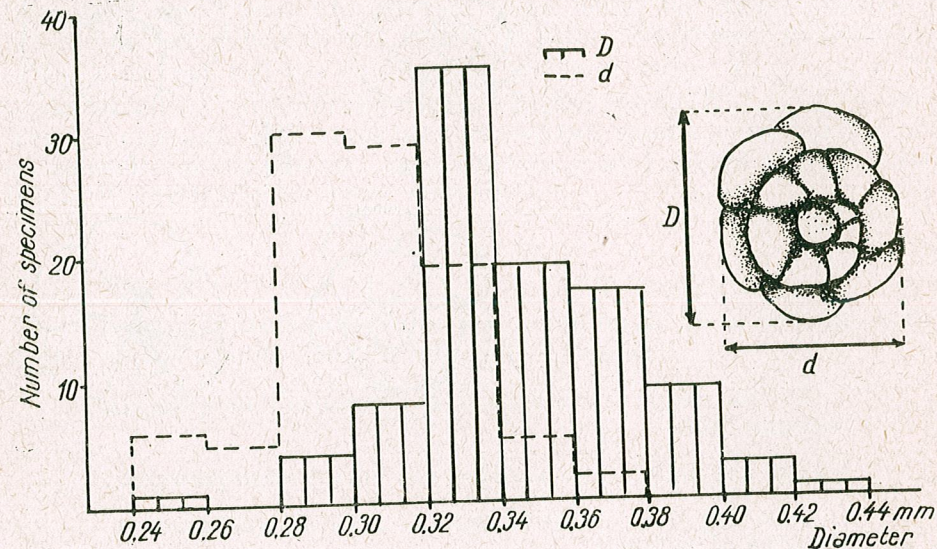
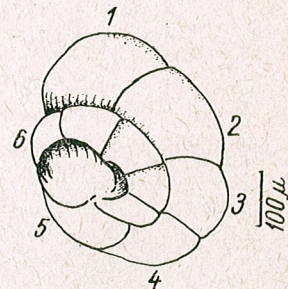


Fig. 3. — Histogram of axial diameter (*D*) and small diameter (*d*) in *Ammonia tepida* (Cushman) from lake Sinoe.

Fig. 4. — Abnormal additional material dorsally on proloculum in an individual of *Ammonia tepida* (Cushman) with slight axial anomaly.



material have been recorded too³ (11 plate 42, Fig. 7b). The forms occurring in lake Sinoe are typical ones in that they lack umbilical material.

In the same sample, among individuals belonging to *Amm. tepida* I found one single microspheric form. The lesser number of microspheric forms is a frequent occurrence with foraminifera from the Black Sea and I have myself witnessed it in a sample from the environs of the Bosphorus in which the ratio of microspheric to megalospheric forms was 1 : 68, i.e.

³ The material deposited on the dorsal side of the proloculum should not be confused with the ventral "umbilical" material.

very low. The phenomenon is thus ruled by the law of small numbers and its rate can be computed. I obtained 4 to 8 per cent microspheric forms corresponding to the ratios 1 : 141 and 1 : 68 respectively, which percentage is the highest to be met in Black Sea samples. The maximum limit

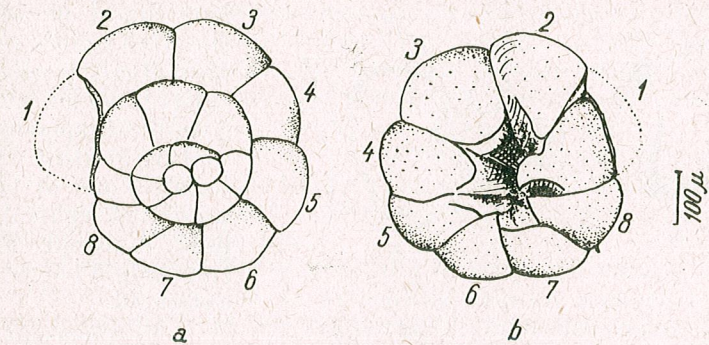
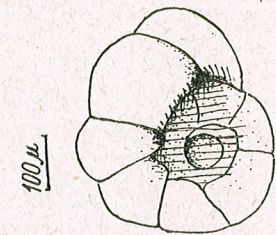


Fig. 5. — Specimen of *Ammonia tepida* (Cushman) having two initial chambers: a = dorsal view; b = ventral view.

is less northward in lake Sinoe (4 per cent) and higher southward (8 per cent) in the sample from Bosphorus.

An interesting fact is that in a number of tests of *Amm. tepida* (Cushman) there have been observed abnormal growths. Such abnormal growths have been in so far recorded in the large foraminifera of the fusulinid

Fig. 6. — Specimen of *Ammonia tepida* (Cushman) having a beginning of spiralization anomaly (dorsal view).



or orbitoid type [12], [13] but not in some widely distributed small-size foraminifera such as the *Rotaliidae* and especially the genus *Ammonia* which have an extremely vast range and live in very different ecological conditions which are not always of the optimum type.

In the specimens from the present sample I found a great number of abnormalities ranging from slight morphological changes to modifications so strong that the specimens are hardly identifiable. Having no other available criterion than the morphological one, I am grouping the abnormal types of tests into four categories, as follows:

1. *Abnormal additional material*. Such instances were observed in five individuals presenting additional material on the dorsal side of proloculum (Fig. 4). While it is probable that the phenomenon occurs with sufficient quantities of water Calcium (Ca^{++}), curiously enough none of the 141 specimens had this material placed ventrally on the proloculum, i.e. umbilically, according to generic characters (*Rotalia* Lamarck

s.l. or *Streblus* Fischer = *Ammonia* Brünnich s.s.) [2], [5], [6], [8], [11]. Some authors have met species or varieties of the genus *Ammonia* that did not present this feature [2-4] while others [1], [2] are doubtful as to the validity of the feature as a generic character. In the sample from

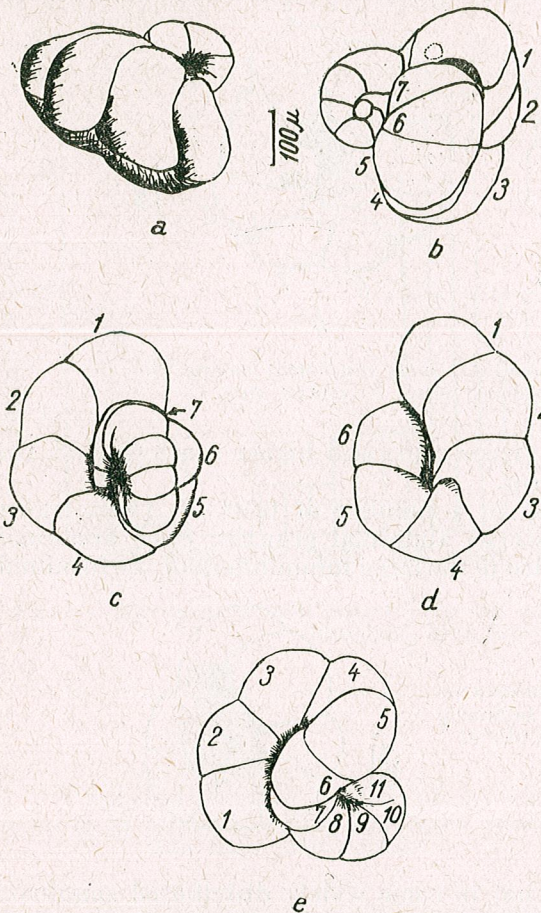


Fig. 7. — Spiralization anomaly with unequal spiral coils: a = side view; b = apertural view; c = dorsal view; d = ventral view; e = side view (based on last coil and aperture).

lake Sinoe, in addition to the five above mentioned individuals presenting excessive dorsal material, I found 18 specimens presenting evident dorsal material. None of the forms presented ventral, "umbilical" material. The criterion should be revised and extended.

2. *Abnormal chambers* were observed in three individuals. Such aberrations affect the shape of one chamber only. These forms seem to be teratological, transitional towards stronger anomalies with axial or coiled plane of spiralization deformations, the latter being more than often accompanied by "abnormal chambers".

Examples of abnormal chambers were found in two individuals in which the penultimate chamber was higher and overreached the remaining chambers with even as much as 37.5μ while having a prolocular diameter of 66.5μ . This anomaly thus represents a half diameter of proloculum. I observed a

similar feature in members of the genus *Nonion* from both lake Sinoe and the Black Sea. Another individual presented the second chamber in the shape of a rounded proloculum instead of a trapezoidal chamber. This resulted in an individual having two "initial chambers" (Fig. 5). Instances of double or triple proloculum had met only in different fusulinids or orbitoids [12], [13]. Garner L. Wilde [13] believes the phenomenon to have one of either following causes:

1. Fusion of individuals of very early stages of development having one chamber (proloculum) or more, the individual thus resulted developed and reached maturity;

2. Certain "diseases" affecting young individuals before they build new chambers. The above mentioned author [13] explains other instances of teratogenesis, for example abnormally coiled forms, in the same manner.

W. S. Cole's hypothesis (1960) reads in conclusion that "multiplication of embryonic chambers is the result of failure of newly megalospheric proloculi to separate" ([12], p. 324).

Both statements fail, however, to furnish an explanation as to the initial cause; they throw some light on the mechanism of the phenomenon. However, it results from both statements that this is a case of balance in the metabolism of young forms.

3. *Axial anomalies*. These were met in three individuals in addition to the one listed in figure 4 as presenting also an abnormal additional material. As it results from this figure, axial anomalies consist in the prolongation of the test in the direction of the large axial diameter (D)⁴ and the shortening of the small perpendicular diameter (d).

4. *Spiralization anomalies*. I found these anomalies in four individuals whose tests were deformed to such a degree that it is hard to say whether they belonged in *Amm. tepida* or not. However, all four specimens belong in the genus *Ammonia* as they all present a series of typical characters of the genus, as for instance two coils of spiral no matter no plane, and the shape of the chambers suggesting, no matter how much modified, the characters of the genus (Figs 6-9). Spiralization anomalies result in a strongly modified appearance of the foraminifera by affecting the spiralization plane of the shell. Frequently, in the adult megalospheric *Ammonia* forms the shell consists of double-coiled chambers that begin at the proloculum. In instances of spiralization anomalies, the coils of the spiral are disposed in different planes building an angle between them (Figs 6, 7, 8) or a part only of a spiral coil is disposed in a different plane (Fig. 9). There is a translation from acute angles of the planes (Fig. 6) to straight angles (90°), the two spiral coils maintaining their normal ratio (Fig. 7) or becoming equal (Fig. 8).

The spiralization anomalies do not affect only the shell coils or parts of them when disposed in different planes, they affect also the chamber shape, thus involving anomalies of chamber structure. Figure 9 on which a deep morphological alteration of each and every chamber is seen is conclusive in this respect. Even in instances of incipient spiralization anomalies (Fig. 6), these are seen to be associated with anomalies of chamber structure.

★

As it can be seen, while the first two types of abnormality affect the shell to a small degree and only locally, the last two types modify it so strongly as to make the identification of forms hazardous (especially

⁴ The axial diameter or large diameter is considered as passing across the last chamber through the centre of the proloculum and reaching the opposite side of the shell, thus being an axe of the dorsal plane (see *D*, Fig. 3).

in the case of spiralization anomalies). Nothing can be said as to the cause or causes of the anomalies and we are compelled to maintain the hypotheses issued by W. S. Cole and Garner L. Wilde. However, what really is of interest is that *Amm. tepida* itself does not enjoy the required conditions since some of its individuals are affected by abnormalities. Physical factors alone cannot be responsible for these phenomena since they comply with tolerated and even optimum limits (e.g. 19.9 g⁰/₁₀₀ salinity [3]). The responsibility while not lying with the physical factor *per se* might well reside in its variation. In this connection, let it be reminded of the high variation of salinity in Razelm lagoon system found lately⁵.

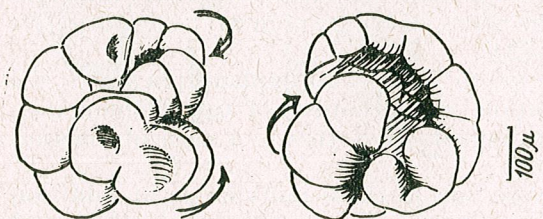


Fig. 8. — Spiralization anomaly with equal coils (no basis for orienting the shell available).

CONCLUSIONS

1. Considering *Ammonia tepida* (Cushman) an independent species, I have mentioned it for the first time from the Black Sea basin with the correct name.

2. At the time of collection of the sample, lake Sinoe was a brackish lake (19.9 g⁰/₁₀₀) with shallow water (less than 3 m depth). Both conditions

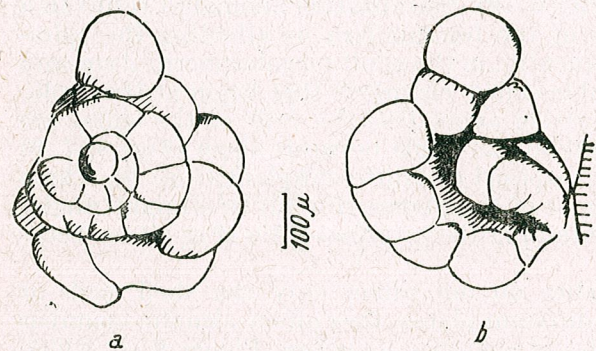


Fig. 9. — Spiralization anomaly with only portion of coil in a different plane than that of the shell (see *b*-arrow): *a*=dorsal view; *b*=ventral view.

3. The abnormalities shown by tests from lake Sinoe depend on the high variability of the salinity factor since salinity *per se* does not exceed the values tolerated by the species and other factors are maintained constant within the optimum limits.

⁵ From 1950 to 1962 salinity in the lake Sinoe dropped from 22 g⁰/₁₀₀ to 10 g⁰/₁₀₀ [14]. In October 1966 the salinities for lake Sinoe looked very much the same as in October 1962, after chemical analysis made by the author, but values were much lesser for lakes Golovița, Razelm and Babadag.

REFERENCES

1. ATANASIU I., SAULEA BOCEC E., Notationes Biol., 1948, **6**, 1-2, 166-177.
2. BERMUDEZ P. J., *Estudio sistematico de los foraminiferos Rotaliformes*, Ministerio de Minas e Hidrocarburos, Ed. Sucre, Caracas, 1952, 71-74.
3. BRADSHAW S. J., J. Paleont., 1957, **31**, 6, 1138-1147.
4. BRODNIOWICZ IRENA, Acta Palaeont. Polonica, Warszawa, 1965, **10**, 2, 131-248.
5. CIFELLI R., Contr. Cushman Found. Foram. Res., 1962, **13**, 4, 119-126.
6. CUSHMAN J. A., Contr. Cushman Found. Foram. Res., 1928, **4**, 4, 103-107.
7. ДІДКОВСЬКИЙ В. Я., Наукові записки Одеської біологічної станції, 1959, **1**, 91-97.
8. ДОЛГОПОЛЬСКАЯ М. А., ПАУЛИ В. П., Труды Карабагской биол. станции, 1932, **4**, 4, 23-53.
9. MACAROVICI N., SEHAN-IONESI BICA, An. St. Univ. "Al. I. Cuza" Iași, Biologie, 1966, **12**, 1, 84-109.
10. PARKER FRANCES L., *Eastern Mediterranean Foraminifera; Reports of the Swedish Deep-Sea Expedition*, 1958.
11. PHLEGER FRED B., PARKER FRANCES L., The Geol. Soc. America, Memoir 46, 1951.
12. SACHS K. N., Micropal., 1964, **10**, 3, 323-329.
13. WILDE GARNER L., Contr. Cushman Found. Foram. Res., 1965, **16**, 3, 121-124.
14. * * *, *Contribution Roumaine à l'étude de la Mer Noire*, Bucharest, 1966.

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are optimum ones for *Ammonia tepida*; however, there occurred a great number of abnormal shells. Based on these I am describing for the first time abnormal growths of the shell in the members of the family Rotaliidae which I am grouping into four categories according to morphological criteria: a) specimens with abnormal additional material; b) abnormal chambers; c) axial anomalies, and d) spiralization anomalies.

SUR QUELQUES MODIFICATIONS MORPHOLOGIQUES
CORRÉLATIVES À L'ABSENCE CONGÉNITALE D'UN ŒIL
CHEZ *SILURUS GLANIS* L.

PAR

OLGA NECRASOV et ECATERINA ADĂSCĂLIȚEI

Utilisant un exemplaire tératologique de silure (*Silurus glanis* L.) présentant l'absence congénitale de l'œil droit et de son nerf, ainsi qu'un développement déficitaire de la fossette olfactive droite — vraie expérience naturelle — les auteurs étudient les modifications survenues dans la musculature du globe oculaire, dans le développement des bulbes olfactifs, du télencéphale et des tubercules optiques.

Notre travail a pour objet l'étude des modifications morphologiques corrélatives à l'absence congénitale du globe oculaire droit, rencontrée chez un exemplaire de silure, mesurant 55 cm, pêché à la station hydrobiologique de Brăila*. Comme matériel de comparaison, nous avons utilisé deux exemplaires normaux de la même taille, appartenant à cette espèce.

I. MODIFICATIONS DANS LA MORPHOLOGIE EXTERNE DE LA RÉGION
CÉPHALIQUE

(Fig. 1 et 2)

A. L'exemplaire tératologique que nous allons étudier ici ne présente qu'un seul œil, celui de gauche, la place où aurait dû se trouver l'œil droit étant entièrement recouverte par la peau. La dissection de la région nous indique l'absence de toute formation, même rudimentaire, pouvant représenter un globe oculaire incomplètement développé. L'œil gauche présente en échange un développement normal à tous les points de vue (position, forme et dimensions).

B. L'étude de la tête nous indique l'existence d'autres anomalies.

1. Le pli commissural est faiblement marqué du côté droit, ce qui donne un aspect asymétrique à la fente buccale.

* Nous prions M. Stelian Beldescu, ancien chargé de recherches à la station, qui a bien voulu nous céder ce matériel, de trouver ici l'expression de nos remerciements les plus vifs.

2. Le barbillon droit offre également une position anormale, puisqu'il se dirige d'abord du côté antérieur, pour se recourber ensuite vers l'arrière, étant donné que le sillon qui se trouve à sa base présente également une direction antérieure (à l'encontre du sillon du barbillon normal, dont le sillon basal a une direction postéro-latérale).

3. Tandis que la fosse olfactive gauche (normale) communique avec l'extérieur par deux orifices distincts (situés chacun à l'extrémité d'une

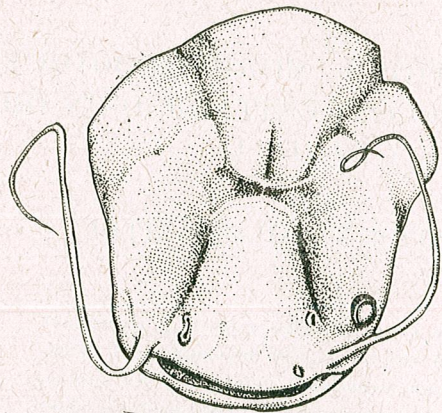


Fig. 1. — Région céphalique du silure à œil droit absent et à narines asymétriques.

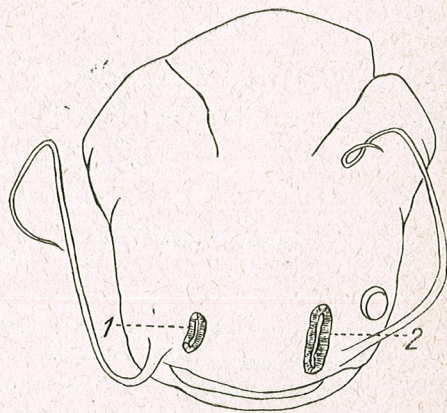


Fig. 2. — Région céphalique de silure à œil droit absent, après excision de la peau, montrant les deux fossettes olfactives de dimensions inégales. 1, F. olf. droite; 2, f. olf. gauche.

petite éminence tubuliforme), la fosse droite présente un seul orifice en forme de boutonnière, en partie recouvert (en avant et latéralement) par un faible repli de la peau. Les dimensions de la fosse droite sont sensiblement moindres (8,8 mm en longueur et 5,0 mm en largeur) que celles de la fosse gauche (13,5 mm en longueur et 5,8 mm en largeur), le nombre des plis dans la première étant corrélativement moindre que dans la seconde, ce qui signifie une surface olfactive également moins importante. On peut en conclure que le facteur ou les facteurs qui ont déterminé le non-développement du globe oculaire droit, ont également agi sur la fosse nasale droite qui présente un développement anormal et déficitaire.

II. MODIFICATIONS DANS LA MUSCULATURE CÉPHALIQUE (Fig. 3, 4 et 5)

La dissection de la musculature opérée des deux côtés de la tête nous indique une profonde perturbation de la musculature droite, touchant en premier lieu la musculature du globe oculaire, mais aussi la musculature céphalique viscérale. A la place où normalement nous aurions dû trouver les quatre droits et les deux obliques, nous trouvons une série de fascicules musculaires dont la plupart purent être identifiés comme suit : Deux fascicules représentant les deux obliques, s'insèrent du côté médial sur le bord antéro-latéral du neurocrâne. Du côté latéral, l'un

d'eux s'insinue entre les deux fascicules (le postérieur et le latéral) de l'adducteur de la mandibule et vient s'insérer sur du tissu conjonctif. Le second se dédouble du côté latéral, formant deux pédicelles qui s'insèrent sur le tissu conjonctif de la partie latérale de la tête. Le pédicelle postérieur

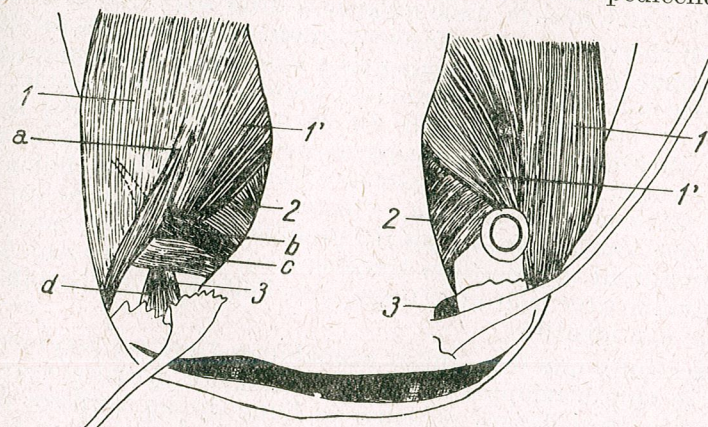


Fig. 3. — Schéma d'ensemble de la musculature céphalique. 1, M. add. de la mandibule; 2, m. élévateur de l'arc palatin; 3, m. du barbillon; a, fascicule superficiel de l'adducteur droit de la mandibule; b, petit oblique; c, grand oblique; d, m. non identifié.

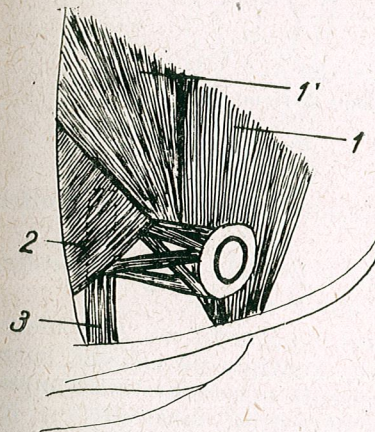


Fig. 4. — Musculature céphalique antérieure de la moitié normale de la tête, laissant à découvert la musculature du globe oculaire. 1, 1', M. add. de la mandibule; 2, m. élévateur de l'arc palatin; 3, m. du barbillon.

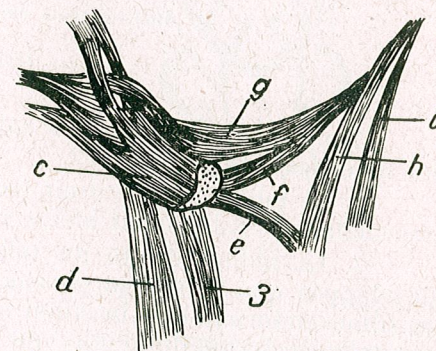


Fig. 5. — Musculature du globe oculaire droit, développée en l'absence de l'œil. c, Grand oblique; d, fascicule non identifié; e, droit inférieur; f, g, deux fascicules du droit externe; h, droit supérieur; i, droit interne.

est percé par le fascicule postérieur du droit externe du globe oculaire qui le traverse.

Les muscles droits offrent une disposition encore plus aberrante. Les droits interne et supérieur s'insèrent par leurs deux extrémités sur

le neurocrâne, ayant une direction presque parasagittale. Le droit externe s'insère d'une part sur le neurocrâne, se dirige ensuite du côté latéral et se divise en deux fascicules dont le postérieur traverse le pédicelle postérieur du grand oblique. Il vient confluer ensuite avec le fascicule antérieur du même muscle, ainsi qu'avec le droit inférieur, avec l'élévateur du barbillon et avec un autre fascicule (dont nous n'avons pas pu établir l'identité), pour former une grande masse musculaire commune qui s'insère dans la masse musculaire de l'adducteur profond de la mandibule. Ajoutons encore que le fascicule antérieur du droit externe traverse le pédicelle postérieur du grand oblique, avant de se réunir au fascicule postérieur du même muscle, au droit inférieur et à l'élévateur du barbillon. Le droit inférieur, faiblement développé, s'insère du côté médial au voisinage du neurocrâne, sur du tissu conjonctif profond. Se dirigeant ensuite du côté latéral (présentant une position transversale), ce muscle vient former une masse commune avec le droit externe, avec l'élévateur du barbillon et avec le fascicule non identifié.

Il en résulte que les somites céphaliques (somites pré-auriculaires I, II et III) se sont développés en l'absence du globe oculaire. Cette absence, en privant la musculature oculaire de l'une de ses surfaces d'insertion, a provoqué des modifications dans la position, la forme et le lieu d'insertion de celle-ci dont le développement ultérieur a été anarchique, produisant par surcroît certaines perturbations dans les masses musculaires voisines, dont surtout l'adducteur de la mandibule et l'élévateur du barbillon.

III. MODIFICATIONS DE L'ENCÉPHALE

A. Modifications dans la morphologie externe

(Fig. 6 et 7)

L'encéphale examiné à la suite de la dissection du neurocrâne, offre les modifications suivantes :

1. Le bulbe olfactif droit (correspondant à la fosse olfactive droite, anormale) est visiblement moins volumineux que le gauche.
2. La moitié droite du télencéphale est également un peu moins développée que la moitié gauche. Sur la face ventrale de celle-ci, entre le sillon endorhinal et le sillon sagittal, apparaît une formation supplémentaire en forme de lobule, qui manque du côté droit, ainsi que sur les encéphales appartenant à des exemplaires normaux (de contrôle).
3. Le nerf optique correspondant à l'œil absent ne s'est point développé.
4. Le tubercule optique gauche (physiologiquement correspondant à l'œil absent) est légèrement moins volumineux que celui de droite, correspondant à l'œil normal. En voici les dimensions :

<i>Tubercule optique</i>	<i>Longueurs</i>	<i>Largeurs</i>
droit	4,7 mm	3,4 mm
gauche	4,4 mm	2,2 mm

B. Modifications dans la structure interne

(Fig. 8, 9 et 10)

L'étude des coupes (6μ), colorées à l'hématoxyline-éosine, nous permet de constater les faits suivants :

1. Le lobule supplémentaire situé sur la partie ventrale de la moitié gauche du télencéphale présente quelques formations cavitaires, alignées

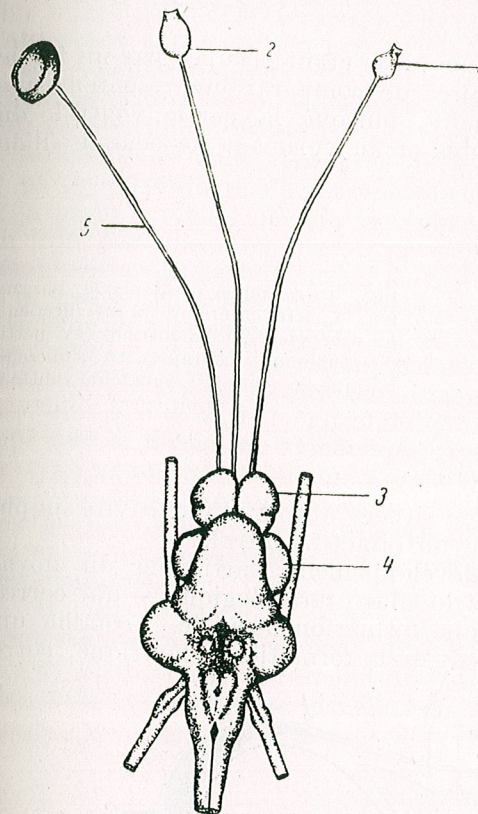


Fig. 6. — Schéma de l'encéphale du silure (vue dorsale) montrant les différences de volume entre les parties symétriques. 1, Bulbe olfactif droit; 2, bulbe olfactif gauche (plus grand que le précédent); 3, télencéphale; 4, mésencéphale (présentant un tubercule optique gauche moins développé que le tubercule droit); 5, nerf optique unique.

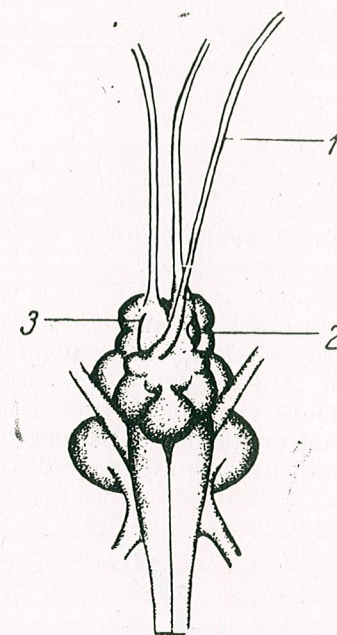
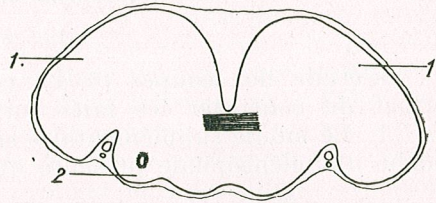


Fig. 7. — Schéma de l'encéphale du silure (vue ventrale). 1, Nerf optique unique; 2, lobule supplémentaire sur la face ventrale de la partie gauche du télencéphale; 3, sillon endorhinal.

dans la direction antéro-postérieure. Ces cavités sont entourées par plusieurs couches de cellules. Celles qui se trouvent au voisinage immédiat de chaque cavité présentent des noyaux de petite taille fortement colorés et sont disposées en 2-3 couches. Celles qui se trouvent à la périphérie de chacune de ces accumulations cellulaires péricavitaires forment 3-4 rangées; elles sont au contraire faiblement colorées et offrent un noyau assez volumineux. Notons que la partie symétrique (droite) ne présente

Fig. 8. — Coupe transversale dans le télencéphale du silure (schéma) montrant la structure du lobule supplémentaire gauche. 1, Partie gauche du télencéphale; 1', partie droite du télencéphale; 2, lobule supplémentaire.



pas de telles formations cavitaires, leur place étant occupée par un faible amas de cellules. Les deux exemplaires de comparaison présentent une situation pour ainsi dire intermédiaire, puisque la partie ventrale du télencéphale y présente des deux côtés et au voisinage de chaque sillon



Fig. 9. — Coupe transversale passant par la partie antérieure du mésencéphale du silure (schéma), montrant l'asymétrie des tubercules optiques. 1, Tubercule optique gauche; 1', tubercule optique droit.

endorhinal, un petit amas de cellules situées autour d'une cavité simple. Ces formations correspondent au noyau olfactif-ventral.

On pourrait interpréter le développement particulier du noyau olfactif-ventral du côté gauche chez le silure tératologique — qui correspond en réalité à l'hypertrophie d'une formation normale — comme une compensation au faible développement de la formation symétrique, corré-

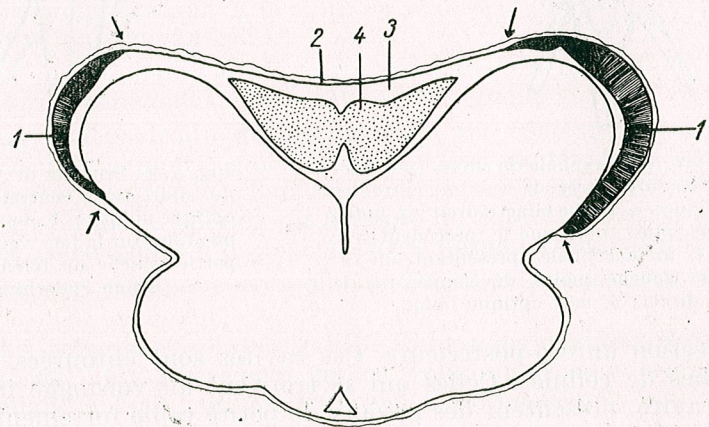


Fig. 10. — Coupe transversale passant par la partie postérieure du mésencéphale du silure (schéma), montrant le développement asymétrique du toit optique et du *vellum anterior*. 1, Toit optique du côté gauche; 1', toit optique du côté droit; 2, *vellum anterior*; 3, ventricule mésencéphalique; 4, valvule du cervelet.

lative à un plus faible développement de la fossette olfactive droite et du bulbe olfactif correspondant.

2. Le toit optique du mésencéphale présente, lui aussi, une asymétrie structurale qui correspond à l'asymétrie du volume des tubercules optiques.

Le toit optique gauche (qui correspond physiologiquement à l'œil absent et qui en aurait dû recevoir les excitations visuelles) est généralement plus mince et moins étendu que le toit droit. Les paquets de fibres qui s'observent entre les couches cellulaires externes et les couches internes y sont moins nombreux. En même temps, les coupes pratiquées dans la région moyenne du mésencéphale nous montrent l'existence d'une solution de continuité entre les couches du toit optique gauche, présentant la forme d'une fente, entourée de cellules. Les coupes pratiquées dans la partie postérieure du mésencéphale nous montrent un amincissement de la paroi nerveuse médiale du tubercule optique gauche, amincissement qui finit par une interruption de celle-ci, le ventricule mésencéphalique y étant recouvert seulement par les méninges. Plus postérieurement encore, au niveau où chez les silures apparaît le vélum antérieur, celui-ci s'étend beaucoup plus du côté gauche, au détriment de la paroi nerveuse. D'autre part, celle-ci s'étend également beaucoup moins vers le bas que du côté droit, ce qui réduit encore davantage son volume à ce niveau. Enfin, observons que le torus longitudinal gauche est aussi plus faiblement développé que la formation symétrique. Pour ce qui est des torus demicirculaires, ils ne marquent aucune asymétrie. La comparaison de ces dispositions avec celles des encéphales appartenant à des exemplaires normaux, nous permet de conclure à un développement déficitaire du tubercule optique gauche, mais pas à une hypertrophie compensatrice de la partie symétrique.

Il faut en conclure, par conséquent, que les éléments principaux du toit optique se développent également du côté gauche, même en l'absence de l'œil qui lui correspond du point de vue fonctionnel et dont il ne reçoit aucune excitation visuelle, mais que ce développement est déficitaire.

CONCLUSIONS

Le silure tératologique étudié dans ce travail nous met en présence d'une expérience naturelle. S'il nous est impossible d'en établir le facteur déterminant, ou plutôt le complexe de facteurs, nous pouvons néanmoins préciser que leur action a commencé à une période très précoce, au moment de la formation des vésicules optiques et des fossettes olfactives. Leur action a atteint le côté droit seulement et a été plus puissante au niveau des premières que des secondes, puisque l'œil droit ne s'est point développé, tandis que la fossette olfactive droite s'est développée d'une manière déficitaire.

Ces deux anomalies, que nous pourrions qualifier de primaires, en ont provoqué d'autres, de différentes importances, affectant en premier lieu le système musculaire et le système nerveux.

Il nous semble particulièrement intéressant que les somites céphaliques se sont développés comme d'ordinaire, donnant naissance aux

muscles du globe oculaire, mais que, en l'absence de cette surface d'insertion, ce développement a été anarchique, provoquant également des perturbations dans d'autres masses musculaires céphaliques.

Nos observations viennent souligner également l'existence d'un rapport étroit entre le développement des organes de sens (partie périphérique de chaque analyseur) et les centres nerveux correspondants, puisque nous avons constaté qu'un moindre développement de la muqueuse olfactive correspond à un bulbe olfactif moins volumineux et à un noyau olfactif ventral du télencéphale moins développé. De même, l'absence du globe oculaire et du nerf respectif correspond à un moindre volume du tubercule optique du côté opposé (physiologiquement correspondant), ainsi qu'à certaines perturbations dans la structure du toit optique (*tectum opticum*) respectif. Cependant, il faut bien souligner que celui-ci s'est développé en l'absence de l'œil, selon son schéma caractéristique héréditaire. Les perturbations structurales que nous y constatons seraient dues, à notre avis, non à la dégénérescence secondaire de certains éléments, mais plutôt à un arrêt de développement, en l'absence de stimuli extérieurs durant les toutes premières phases de la vie post-embryonnaire. Il nous semble que les excitations optiques reçues pendant ces premières phases de la vie active (larve, alevin) doivent contribuer à l'achèvement des structures des centres optiques de l'encéphale, en stimulant les dernières divisions cellulaires. Il nous semble également que cela pourrait expliquer, en général, l'existence de relations quantitatives entre le développement des récepteurs et celui des centres nerveux correspondants. Dans tous les cas, nous nous proposons d'approfondir ce problème par des recherches expérimentales sur les larves et les alevins du silure et encore d'autres espèces.

BIBLIOGRAPHIE

1. ARIENS-KAPPERS C.U., *Die vergleichende Anatomie des Nervensystems der Wirbeltiere und des Menschen*. Ed. De Erven F. Bohn, Haarlem, 1921.
2. — *Feinere Bau- und Bahnverbindungen des Zentralnervensystems*, in L. BOLK, E. GÖPPERT, E. KALLIUS, W. LUBOSCH, *Handb. d. vergleichenden Anatomie der Wirbeltiere*. Ed. Urban & Schwarzenberg, Berlin-Wien, 1934, II, 1.
3. BERTIN L., *Système nerveux*, in P. GRASSÉ, *Traité de Zoologie*, Ed. Masson, Paris, 1958, XIII, 1.
4. HALLER V., HALLERSTEIN V., *Zerebrospinale Nervensystem*, in L. BOLK, E. GÖPPERT, E. KALLIUS, W. LUBOSCH, *Handb. d. vergleichenden Anatomie der Wirbeltiere*, Ed. Urban & Schwarzenberg, Berlin-Wien, 1934, II, 1.
5. LE DANOIS Y., *Système musculaire*, in P. GRASSÉ, *Traité de Zoologie*, Ed. Masson, Paris, 1958, XIII, 1.
6. ROCHON-DUVIGNEAUD A., *L'œil et la vision*, in P. GRASSÉ, *Traité de Zoologie*, Ed. Masson, Paris, 1958, XIII, 2.

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Chaire de Morphologie animale et Anthropologie

DAS REIZLEITUNGSSYSTEM DES HERZENS BEIM HAUSGEFLÜGEL

VON

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The gross anatomical and microscopical studies on the specific conducting system of the heart in some species of domestic birds, revealed similarities and differences as against the mammalian heart. The autonomic system is more developed in birds than in mammals. The specific fibres give up many branches which are following blood vessels of arterial type. In birds the specific fibres are not embedded in a connective tissue sheath as in mammals, but are in a very close connection with the arterioles which they follow. The structural characteristics are the same as in mammals.

Im Vergleich zu den zahlreichen Abhandlungen aus der einschlägigen Literatur über den morphologischen Bau des Herzens bei den Säugetieren, sind Arbeiten auf diesem Gebiet beim Hausgeflügel nur sehr spärlich vorhanden; letztere beziehen sich hauptsächlich auf Beschreibungen über den anatomischen Aufbau des Herzens mit seinen Muskel- und Gefäßsystemen. Die einzige uns bekannte Arbeit über das Reizleitungssystem des Herzens beim Hausgeflügel ist diejenige von F. Davies (1930); er versuchte das autonome Reizleitungssystem des Vogelherzens augenscheinlich zu machen und das Faserwerk desselben im Herzmuskel zu beschreiben. In den später erschienenen Arbeiten auf diesem Gebiet ist das Augenmerk hauptsächlich auf die Ultrastruktur der Herzmuskelfasern gerichtet, besonders in ihrer embryonalen Entwicklung und beim Junggeflügel (Lindner 1957, Muir 1957, Hibbs 1956, Schulze 1961); in diesen Arbeiten wird jedoch kein vergleichendes Bild über das Reizleitungssystem des Herzens erwähnt.

Um den Gesamtaufbau des autonomen Reizleitungssystems des Herzens beim Hausgeflügel (Pute, Gans, Ente und Huhn) sichtbar zu machen, haben wir zahlreiche Versuche mit den verschiedensten Methoden, wie z. B. durch Injektionen, Korrosion, durch Färbungs- und Aufhellungsmethoden (nach Spalteholz), durchgeführt. Brauchbare Ergeb-

nisse konnten wir nur mit den letzten drei Verfahren erzielen, während Injektionen in die bindegewebigen Faserhüllen, eine Methode die am Herzen der Säugetiere erfolgreich angewendet werden kann, beim Hausgeflügel keine zufriedenstellenden Ergebnisse ergaben. Auf die Ursachen dieses Umstandes wird in den weiteren Ausführungen näher eingegangen.

Zum mikroskopischen Studium der spezifischen Fasern, wurden die diesbezüglichen Proben in 10%iger Formollösung sowie in Gemischen nach Bouin und Serra sowie nach

Carnoy fixiert. Die Färbung der Präparate wurde mit „Azan“, Eisenhämatoxylin nach Heidenhain, Hämalaun-Eosin und Methylblau durchgeführt. Silberimprägnationen nach Cajal und Landau, die Feulgensche Reaktion (Feulgen und Rosenbeck), Pyronin-Methylgrün- (nach Brachet) und PAS-Färbungen (nach Lillie), wurden auch durchgeführt.

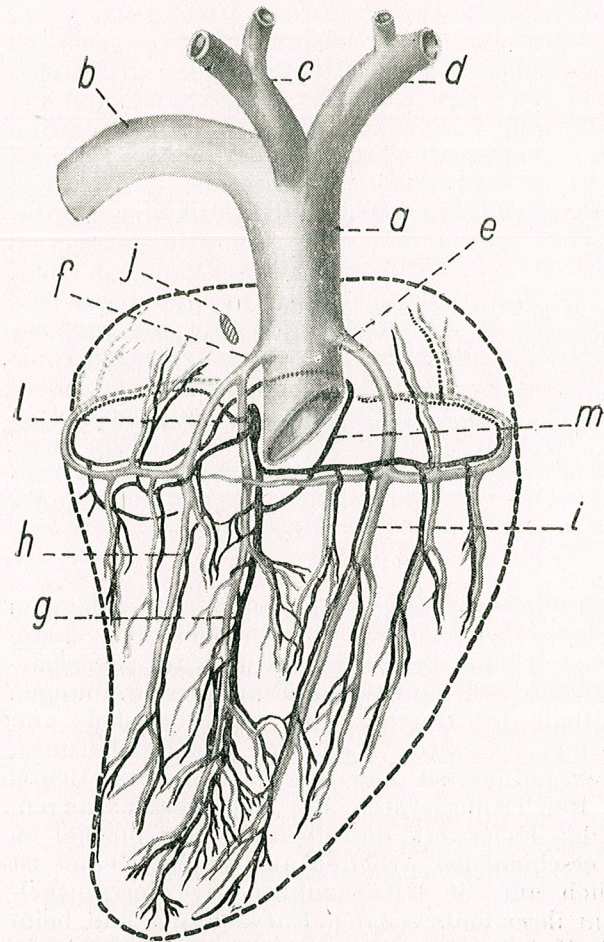


Abb. 1. — Schema des Reizleitungssystems der Vögel.
a, Aorta; b, Aorta descendens; c, A. brachiocephalica dextra; d, A. brachiocephalica sinistra; e, Arteria coronaria sinistra; f, Arteria coronaria dextra; g, A. septoventricularis; h, A. interventricularis dextra; i, A. interventricularis sinistra; j, Sinuatrialknoten; l, Aschoff-Tawarascher Knoten; m, Fasc. recurrens aus dem Knotenfaserbündel.

Der *Sinuatrialknoten* (Keith-Flack) befindet sich zwischen den beiden Öffnungen der hinteren und vorderen Hohlvenen, in der Muskelwand der rechten Vorkammer. Seine Größe ist diejenige eines Hirsenkorns (Abb. 1, j).

BESPRECHUNG DER ERGEBNISSE

Die makroskopischen Untersuchungen des autonomen Reizleitungssystems am Herzen des Hausgeflügels erbrachten einige spezifische Eigenschaften. Die dem Sinusknoten entspringenden Fasern werden zu Begleitern derjenigen die Herzkammern speisenden Blutgefäße, die ihren Ursprung in der rechten und linken Kranzarterien haben. Außer der rechten Interventrikulararterie und zahlreichen sekundären Arterien, entspringt aus der rechten Kranzarterie auch die A. septo-ventricularis, die die Zwischenherzkammerwand mit Blut versorgt.

Der *Atrioventrikularknoten* (Aschoff-Tawara) befindet sich an der Basis des Septum interventriculare, zur rechten Seite des Aortenringes, an der Stelle, wo die A. septo-ventricularis aus der rechten Kranzarterie ihren Ursprung nimmt. Seine Größe ist ebenfalls diejenige eines Hirsenkorns (Abb. 1, l).

Das *Atrioventrikularbündel* (His) beginnt im unteren Teil des Atrioventrikularknotens und verläuft abwärts, zusammen mit sämtlichen sekundären Arterien, die aus den beiden Kranzarterien ihren Ursprung nehmen. Das weitaus am stärksten entwickelte Faserbündel begleitet die A. septo-ventricularis (die aus der rechten Kranzarterie entspringt), um die es einen reichen Plexus bildet. Bemerkenswert ist, daß die Arterie in den tieferen Schichten der Scheidewand verläuft, während das Muskelfaserbündel, das sich zu Beginn ebenfalls in den tieferen Schichten befindet, im Bereich seines mittleren Verlaufs, Bündel abgibt, die die Scheidewand nach beiden Seiten quer durchziehen und an der Wandinnenfläche vom Endocardium umhüllt werden. Die Faserzüge unterscheiden sich vom Herzmuskel durch ihr graufarbiges Aussehen, so daß ihr Verlauf mit einer Lupe gut verfolgt werden kann. In seinem subendocardialen Verlauf gibt das Faserbündel des Septums mehrere Verzweigungen ab, die sich in den Trabeculae carneae verbreiten und vermittels dieser die lateralen Ventrikularwände erreichen (Taf. I, A). Zu bemerken ist, daß am Ursprung dieses Bündels ein aufsteigender Faserzug abzweigt (Fasc. recurrens. Abb. 1, m), der die Aorta in Richtung von links nach rechts umkreist und hier einen Ring um die Atrioventrikularöffnung bildet. Aus diesem Bündel entspringen Fasern, die auf der Oberfläche der Herzklappen verlaufen (Taf. I, B, f) und in den Mm. valvulo-marginales enden.

Sämtliche Gefäße, die den Kranzarterien entspringen werden von Faserzügen begleitet, die ihren Ursprung im Atrioventrikularknoten haben. Diese Faserzüge verlaufen parallel mit diesen Gefäßen und geben an der Herzoberfläche Verbindungen mit einem anderen Fasersystem ein.

Im Vergleich zu dem autonomen Reizleitungssystem der Säugetiere, ist dasjenige des Hausgeflügels, durch seine vielfachen Verzweigungen, weitaus stärker entwickelt. Diesem Umstand ist es zu verdanken, daß die normale Anzahl der Pulsschläge bei den Vögeln im Ruhestand im allgemeinen größer ist, als bei einem Säugetier von gleicher Körpergröße. Zugleich gilt diese Tatsache auch zur Aufklärung der hohen Pulsfrequenz bei den Vögeln.

Im histologischen Bau der Elemente des autonomen Reizleitungssystems beim Geflügel, der an Schnittpräparaten der Außenwände der Vorkammern und Kammern des Herzens, sowie an den entsprechenden Zwischenwänden untersucht wurde, kann bei sämtlichen untersuchten Hausgeflügelarten das Vorhandensein einiger gemeinsamer baulicher Eigenheiten erkannt werden.

Die spezifischen Fasern des autonomen Reizleitungssystems, die im Bereiche des Zentralbündels gruppenartig angeordnet sind, verzweigen sich bald und begleiten in ihrem weiteren Verlauf die Blutgefäße, die im Epicardium und Myocardium sehr zahlreich vorhanden sind (Taf. II, A). Die Zahl der spezifischen Begleitfasern der einzelnen Gefäße ist verhältnismäßig gering, in den meisten Fällen bestehen sie nur aus

einem einzigen Zellstrang. Je weiter diese Fasern in die tieferen Lagen des Myocardiums eindringen, werden sie so dünn, daß sie nur noch schwer von den normalen Muskelfasern des Myocardiums unterschieden werden können.

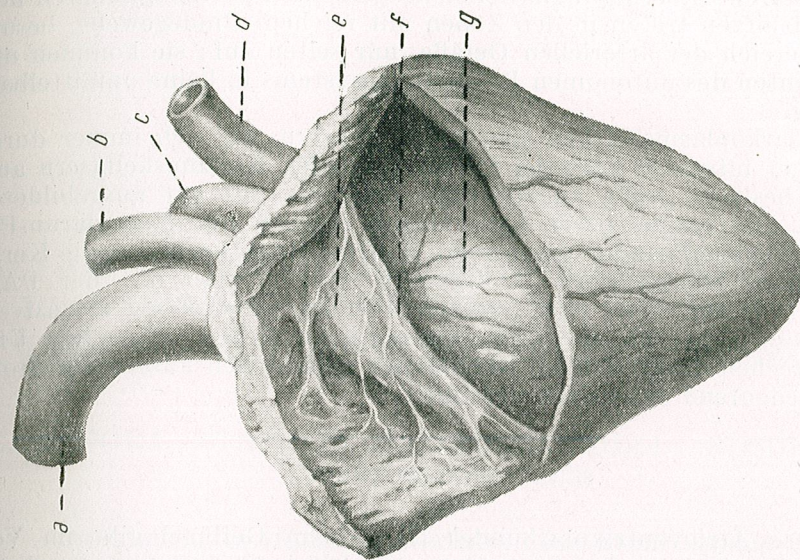
In Querschnitten, besonders im Bereich arterieller Blutgefäße, kann beobachtet werden, daß die spezifischen Fasern des autonomen Reizleitungssystems in ein die Gefäße umgebendes lockeres Bindegewebe eingebettet sind. Eine bindegewebige Scheide, die den spezifischen Fasern eng anliegt, um ähnlich wie bei dem entsprechenden Bau der Säugetiere eine selbständige Hülle zu bilden, kann beim Geflügel nicht beobachtet werden. Aus diesem Grunde ist die Injektionsmethode zur makroskopischen Darstellung der Fasern des autonomen Reizleitungssystems beim Geflügel nicht anwendbar.

Bei Blutgefäßen kleineren Kalibers, nimmt während ihres Verlaufes die Menge des sie umgebenden Bindegewebes allmählich ab, so daß die spezifischen Fasern, bei Azan- oder Hämalaun-Eosin- und Methylblaufärbung, nur noch eine ganz enge, intensiv grau gefärbte Grenzzone aufweisen (Taf. II, B). Sobald die Fasern in die tieferen Schichten des Herzmuskels eindringen, nimmt auch die intensivere Färbung der Grenzzone allmählich ab.

Von besonderem Interesse ist die Tatsache, daß das Verhältnis zwischen den spezifischen Fasern und den ihnen entsprechenden Blutgefäßen, nicht einheitlich ist. Während im Bereich der größeren Blutgefäße die spezifischen Fasern vom Bindegewebe der Blutgefäße eingehüllt werden (Taf. II, B), schmiegen sich im Bereich der kleineren Blutgefäße, die Fasern eng an die Wände der entsprechenden Gefäße an. An einzelnen Querschnitten konnte sogar erkannt werden, daß die Spezialfasern die Gefäße muffartig umkleiden. (Taf. II, D).

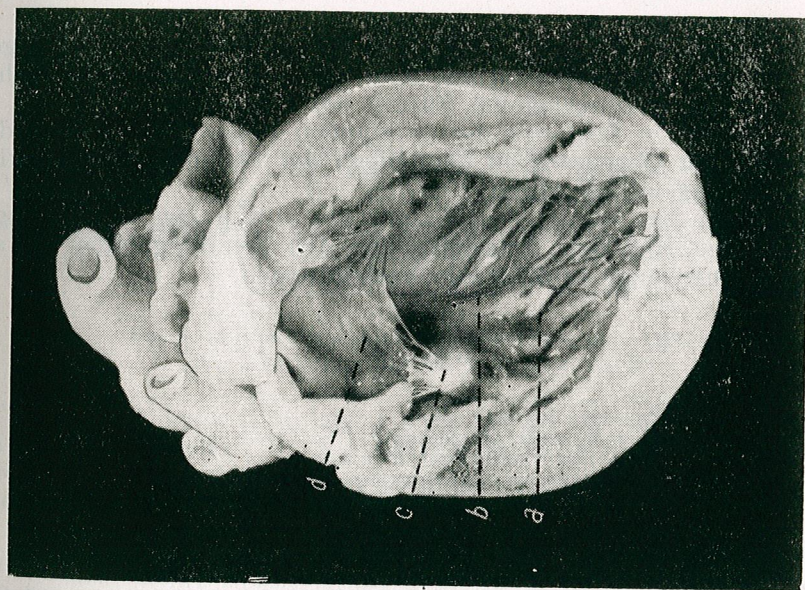
In all jenen Fällen, in denen die Spezialfasern selbständig zwischen den normalen Muskelfasern des Myocardiums verlaufen, z. B. an den besonders stark ausgebildeten Wandteilen der linken Herzkammer, schließen sich diese eng an das Perimysium an. Manchmal scheint es sogar, als ob sich die Spezialfasern innerhalb des Perimysiums der normalen Muskelfasern befinden. In diesen Fällen unterscheiden sich die Spezialfasern von den Muskelfasern bloß durch die weniger intensive Färbung und durch ihre etwas größeren Ausmaße, im Vergleich mit den sie umgebenden Muskelfasern. Eingehendere weitere Studien dieses Phänomens würden einen wertvollen Beweis liefern zu Gunsten der Theorie über den myogenen Ursprung der spezifischen Fasern des Reizleitungssystems des Herzens.

Aufgrund der optischen Mikroskopie konnten vom zytologischen Standpunkt keine strukturellen Unterschiede der spezifischen Fasern bei den untersuchten Hausgeflügelarten nachgewiesen werden. Durch ihren großen Sarkoplasmagehalt, durch die geringe Myofibrillenanzahl und ihre Färbungsaffinität ähneln sie den spezifischen Fasern der Säugetiere. Im Rahmen der Hausvögelgattungen erscheint die geringe Variabilität der Größenmaße als besonders bezeichnend. Anscheinend sind diese Maße bei der Gans und der Ente etwas größer und bei der Pute und ganz besonders beim Huhn geringer.



B, Ventriculus dexter beim Truthahn.

a, Aorta descendens; b, A. brachiocephalica dextra; c, A. brachiocephalica sinistra; d, A. pulmonalis; e, Valvula muscularia; f, Fasc. recurrens aus dem Knotenfaserbündel; g, Septum interventriculare.



Tafel I A, Ventriculus sinister beim Truthahn.

a, Septum interventriculare; b, Fasciculum septale; c, M. papillaris; d, Valvula bicuspidalis.

Die durch Silberimprägnationen festgestellten postganglionären nervösen Endspitzen treten in den Zonen mit reichem Bindegewebe, besonders im Bereich der arteriellen Gefäße, nur selten auf; sie kommen mit den Elementen des autonomen Reizleitungssystems in keine unmittelbare Berührung.

Die sarkoplasmareichen spezifischen Fasern, die sich immer durch eine weniger intensive Färbung als die normalen Herzmuskelfasern auszeichnen, besitzen große kugelförmige Zellkerne mit gut ausgebildeten Nucleolen. Die Kerne dieser Zellelemente ergeben mit Methylgrün-Pyronin und Feulgenfärbung intensivere positive Reaktionen, als die Kerne der normalen Muskelfasern. Andererseits erreicht man mit der PAS-Reaktion, obwohl diese nur schwach ausfällt, eine etwas intensivere Färbung, im Vergleich zu derjenigen normaler Zellen. Alle diese Umstände sprechen dafür, daß im Bereich der spezifischen Fasern der Stoffwechsel bedeutend intensiver verläuft.

SCHLUSSFOLGERUNGEN

1. Das Atrioventrikularbündel (His) beim Geflügel gibt im Vergleich zu demjenigen der Säugetiere, zahlreichere Verzweigungen ab, die alle arteriellen Gefäße, sowohl an der Oberfläche als auch in den tieferen Schichten der Herzwände, begleiten.

2. Das autonome Reizleitungssystem der Vögel ist im allgemeinen stärker ausgebildet als bei den Säugetieren. Dieser Umstand wird unmittelbar durch die spezifische Lebensweise der entsprechenden Tierarten bestimmt.

3. Die spezifischen Fasern des Reizleitungssystems der Vögel zeigen strukturell keine charakteristischen Abweichungen vom histomorphologischen Bau der entsprechenden Fasern der Säugetiere.

4. Die baulichen Elemente des autonomen Reizleitungssystems der Vögel besitzen, im Gegensatz zu denjenigen der Säugetiere, keine klar ausgeprägte bindegewebige Hülle.

5. Zwischen den spezifischen Fasern des autonomen Reizleitungssystems der Vögel und den Arteriolen und den Kapillargefäßen die sie begleiten, bestehen enge funktionelle Verbindungen.

LITERATUR

1. DAVIES F., J. Anat., 1930, 64, 129–144.
2. LINDNER E., Verh. Anat. Ges., 1957, 54, 305–317.
3. MUIR M. R., J. Biophys. Biochem. Cytol., 1957, 3, 251–258.
4. SCHULTZE W., Zeitschr. f. mikr. Anat. Forschung, 1962, 68, 2, 271–274.

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ACTION DE TRÈS FAIBLES DOSES DE RAYONS γ SUR LA RESPIRATION TISSULAIRE DU FOIE DE LA GRENOUILLE PENDANT LE RÉVEIL PRINTANIER

PAR

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Dans quelques travaux antérieurs nous avons signalé l'action stimulante de très faibles doses de radiations γ , sur certains phénomènes cellulaires et tissulaires [4], [5], [6], [7]. A la suite de ces recherches nous pensons que les deux limites de l'échelle de doses, les doses très faibles et les doses très fortes, ont des actions antagonistes sur certains phénomènes physiologiques (fig. 1). C'est pour cela que nous avons proposé

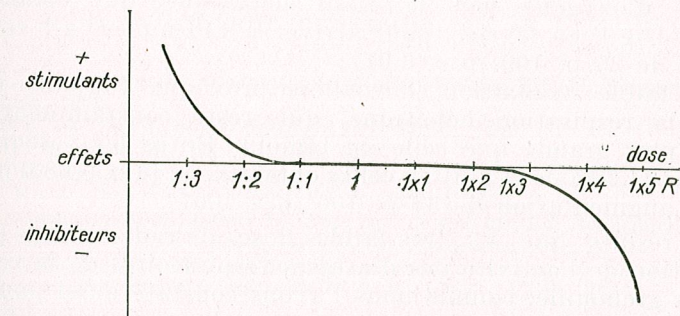


Fig. 1. — Effets stimulants et inhibiteurs des radiations ionisantes en fonction de la dose (en R).

d'utiliser les doses stimulantes dans les cas de fortes irradiations ou de la maladie actinique [8]. Nous avons donné le nom d'*homéopathie radiobiologique* à cet effet positif provoqué par de très faibles doses de radiations ionisantes.

En poursuivant des recherches pareilles nous présentons dans la note présente l'action homéopathique d'une très faible dose journalière de rayon γ sur la respiration tissulaire du foie de la grenouille (*Rana esculenta*) pendant le printemps, alors que les animaux passent de la vie

au ralenti d'hiver, à une vie d'une intense activité métabolique (formation de produits sexuels) et dynamique (déplacement actif pour l'accouplement et pour la nourriture).

Nous avons mesuré la respiration tissulaire du foie pendant le mois de février sur des grenouilles encore inertes; à la fin d'avril et au début de mai sur des animaux en pleine maturité sexuelle et à la fin de juin, sur des individus complètement libres. Pour chaque période nous avons

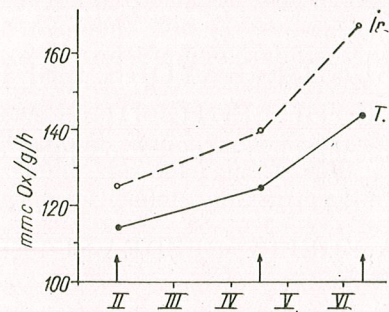


Fig. 2. — Valeurs de la respiration du tissu hépatique de la grenouille (en mme O/g/h) en fonction du temps (mois) chez les animaux témoins (T) et chez les animaux irradiés (Ir) avec de très faibles doses de rayons γ .

institué deux lots contenant chacun 10 mâles : un lot témoin et un lot d'animaux irradiés journallement pendant deux heures avec 144 mR de rayons γ fournis par une source de Co^{60} de 25 mCi, à une distance de 50 cm. L'irradiation a duré 10 jours. Les animaux ont reçu en total 1440 mR c'est-à-dire 1,44 R.

La respiration tissulaire du foie a été mesurée par la méthode de Warburg, à une température de $+22^{\circ}\text{C}$ pendant une heure, en utilisant la solution de Ringer comme milieu respiratoire.

Dans la figure 2 nous présentons les résultats moyens obtenus pour les deux lots. On constate :

— une augmentation de la consommation d'oxygène par le tissu hépatique, qui commence avec 114,8 mme O/g/h en février, pour arriver à 143 mme O/g/h en juin, donc une hausse de 25 p. 100 ($p < 0,01$);

— la faible irradiation journalière provoque toujours une stimulation de la respiration hépatique, qui reste constamment d'environ 10 p. 100 plus grande que celle du témoin. Entre les valeurs obtenues en février (125,2 mme O/g/h) et celles obtenues en juin (168,0 mme O/g/h) il y a une augmentation de 34 p. 100 ($p < 0,01$).

Il en résulte que les très faibles doses de radiations γ provoquent une activation de l'activité des diastases respiratoires de la cellule hépatique de la grenouille, comme nous l'avons constaté aussi pour la cellule hépatique du rat [5]. Il est possible que sous l'action de très faibles doses

Tableau 1

Consommation d'oxygène du tissu hépatique des grenouilles normales et irradiées, en mme/g/heure. Chaque chiffre représente la moyenne de 10 individus

	Février		Avril-Mai		Juin	
	Tém.	Irr.	Tém.	Irr.	Tém.	Irr.
Moyenne	114,8	125,2	124,5	139,9	143,8	168,0
E.S. \pm %	8	8,7	13	6	15	15
Diff. \pm % témoins		+9%		+12%		+17%

de rayons γ , dans la cellule du foie apparaissent certaines substances non toxiques nouvelles, qui provoquent la stimulation des diastases respiratoires.

Nous sommes sûrs que l'action de fortes doses de radiations ionisantes se ressent surtout sur les grands mécanismes de réglage de l'organisme entier. Les fortes doses provoquent des troubles dans l'homéostasie générale de l'individu, qui sont la conséquence de certaines lésions biochimiques, capables de libérer des substances toxiques [1], [2], [3].

L'action de très faibles doses s'exerce au niveau intracellulaire, sur des organites comme les mitochondries, les ribosomes, etc., qui sont des formations vivantes très sensibles. La petite quantité d'énergie qui arrive jusqu'à ces organites, par les faibles doses de rayonnements, provoque une stimulation des réactions diastatiques et énergétiques de la cellule.

Cette différence du lieu d'action est sûrement la cause de leur différence de résultat : les fortes doses ont des actions négatives, les faibles doses ont des actions positives sur la matière vivante constituée en organismes (voir la fig. 1).

Certaines expériences qui sont en cours dans notre laboratoire sur des rats blancs, nous ont révélé que la survie des animaux exposés à une dose de 800 R ($\text{DL}_{50/30}$) et maintenus immédiatement après à un rayonnement de très faible dose (40 mR/h), est plus longue que la survie des mêmes animaux non maintenus à une faible irradiation.

La question de la très faible dose de radiations ionisantes se présente donc comme l'une de la plus haute importance dans la radiobiologie actuelle.

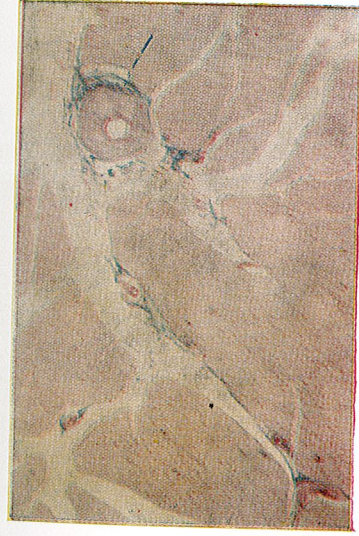
BIBLIOGRAPHIE

1. BACQ Z. M., ALEXANDER P., *Fundamentals of Radiobiology*, Ed. II, Pergamon Press, Oxford, 1963.
2. ГРАЕВСКИ Е. А., Усп. совр. биол., 1954, 37, 2, 158.
3. ОРБЕЛИ Л. А., Реф. Ж. Биол., 1956, 5, 87.
4. PORA E. A., MANCIULEA ȘT., *Doze mici de radiații*, Ed. Academiei, 1966, p. 156.
5. PORA E. A., KIS Z., *Doze mici de radiații*, Ed. Academiei, 1966, p. 163.
6. PORA E. A., GHIRCOIAȘIU M., BEREY E., *Doze mici de radiații*, Ed. Academiei, 1966, p. 175.
7. PORA E. A., PERSECA T., *Doze mici de radiații*, Ed. Academiei, 1966, p. 171.
8. PORA E. A., *Influence des microdoses (mR) des radiations γ sur certains phénomènes physiologiques*. 2^e Conférence nationale de radiobiologie, Varna, 1967.

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TAFEL II



A, Schnitt in die linke Herzkammer der Ente. Serra, Azan, Ok. 8, Ob. 10.



B, Längsschnitt der spezifischen Faser des autonomen Reizleitungssystems der Ente. Serra, Azan, Ok. 6, Ob., 40.



C, Querschnitt am Myocard des Ventrikels im Bereich einer Arterie. Serra, Azan, Ok. 8, Ob. 25.



D, Schnitt in die rechte Herzkammerwand der Ente. Formol, Azan, Ok. 10, Ob. 40.

RESEARCHES ON GLYCEMIA IN NEWTS

BY

CONSTANȚA MATEI-VLĂDESCU

We studied the variation of glycemia during inanition, the glyceimic differences according to sex, the course of induced hyperglycemia and the influence of insulin and adrenalin upon glycemia, in *Triturus montandoni* and *Triturus alpestris*. In the reproduction period, glycemia was higher in males than in females, namely 96 ± 3.50 mg/100 ml as against 85 ± 3.27 mg/100 ml in *T. alpestris* and 105 ± 3.18 mg/100 ml as against 93 ± 4.44 mg/100 ml in *T. montandoni*. Glycemia diminished very slowly during inanition.

Hyperglycemic state induced by 1 g glucose/kg b.w. was solved in some 6 hours. The minimum hormone doses effective in modification of glycemia were of 0.5 IU insulin/kg and respectively, of 10 μ g adrenalin/kg.

The analysis of the data from literature concerning the glyceimic level of urodels [2], [4], [8], [9] shows the existence of great differences between species.

For completing these data, we have undertaken researches on glycemia and its regulation in two species of urodels (*T. montandoni* and *T. alpestris*) which have not yet been studied from this point of view.

MATERIAL AND METHODS

The experiments were carried out at the Sinaia zoological station, in Spring (April — May), on animals which were in the reproduction period.

The number and weight of the individuals utilized for the experiments are given in table 1. The tritons were kept in aquariums with a large quantity of water, corresponding to their exclusive aquatic way of life during the reproduction period. The water temperature in the aquariums varied between 17° and 21°C. During the entire course of the experiments, the animals received no nourishment.

The blood was taken by the decapitation of the previously heparinized animals. The quantity of blood for one test was obtained in most cases from 2—3 individuals.

Table 1
Average number and weight of individuals

Item	Species	Number		Weight g	
		♂	♀	♂	♀
1	<i>T. alpestris</i>	50	54	2.43 (2.2-2.58)	4.34 (3.11-6.00)
2	<i>T. montandoni</i>	60	100	2.20 (1.8-2.50)	2.90 (2.70-3.40)

The dosing of glycemia was made by the Hagedorn-Jensen method.

Hyperglycemia was induced by the intraperitoneal administration of certain aqueous solutions of glucose, in an 1 g/kg b.w. dose.

For the study of the action of insulin and adrenalin "Biofarm" insulin with 40 UI/ml, and 1⁰/₁₀₀ "Biofarm" adrenalin were employed, diluted with saline solution and injected intraperitoneally in various experimental doses.

The volume of the glucose solution or of the hormone administered was of 0.2-0.3 ml/10 g b.w.

RESULTS OBTAINED

In both species we investigated the variation of glycemia during inanition, the glyceimic differences according to sex, the course of induced hyperglycemia and the modification of glycemia under the action of insulin and adrenalin.

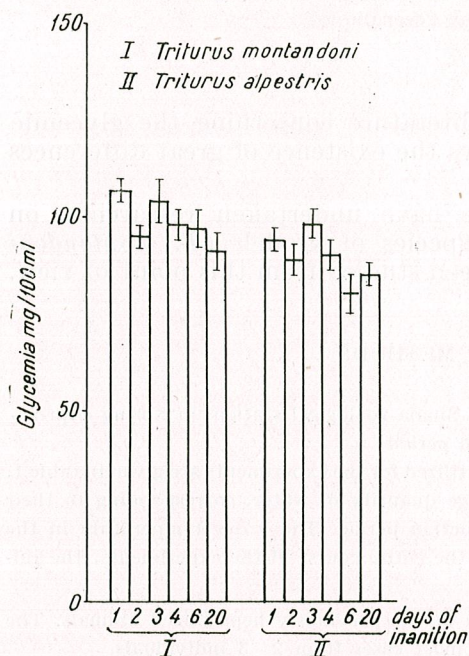


Fig. 1. — The influence of inanition on glycemia in *T. montandoni* and *T. alpestris*.

THE INFLUENCE OF INANITION

In lots of newts, each made up of 15 to 20 specimens, glycemia was dosed at different time intervals from the capture and the bringing into the laboratory (1, 2, 3, 4, 6 and 20 days). In dosages made after 24 hours from capturing the animals, glycemia amounted to 107 ± 1.4 mg/100 ml in *Triturus montandoni* and 94 ± 2.98 mg/100 ml in *Triturus alpestris*.

As may be seen from figure 1, the glyceimic values oscillated in the first three days around the above mentioned values, after which a gradual decrease in glycemia occurred, which even after 20 days of inanition had but a relative significance ($p = 0.5$).

GLYCEMIC DIFFERENCES ACCORDING TO SEX

Glycemia was dosed comparatively in lots of 20-30 adult specimens, males and females, gathered in the same day and kept in identical conditions.

Table 2
Glyceimic differences according to sex

Item	Glycemia mg/100 ml			
	<i>T. montandoni</i>		<i>T. alpestris</i>	
	♂	♀	♂	♀
1	80	71	76	69
2	90	72	79	72
3	92	74	82	73
4	98	75	95	81
5	100	81	96	83
6	107	87	102	86
7	113	90	103	86
8	111	92	105	87
9	112	92	105	88
10	113	100	105	88
11	114	100	110	94
12	116	104	—	99
13	116	105	—	116
14	120	110	—	—
15	—	113	—	—
16	—	119	—	—
M	105 ± 3.18	93 ± 4.44	96 ± 3.50	85 ± 3.27

We ascertained that in both *T. montandoni* and *T. alpestris*, glycemia was higher in males than in females (Table 2).

INDUCED HYPERGLYCEMIA

The intraperitoneal administration of glucose in the dose of 1 g/kg induced in both species a hyperglycemia which reached its maximum values in the first hour. After 6 hours, glycemia reverted almost to the initial values, and decreased after 24 hours even below these values ($p < 0.01$ (Fig. 2)).

THE ACTION OF INSULIN

Most experiments were carried out on

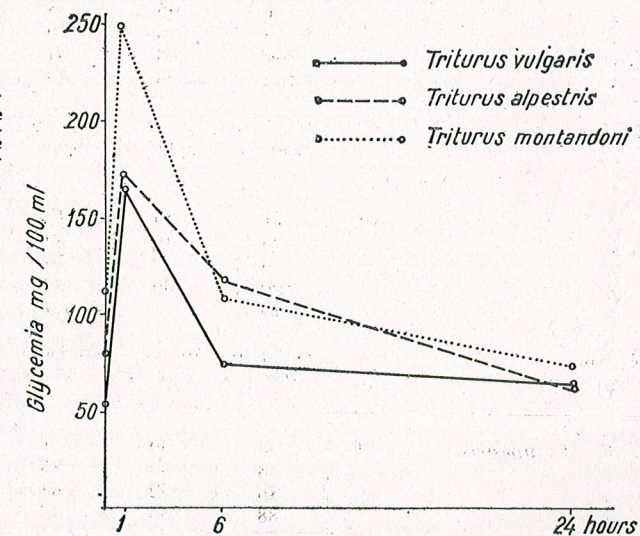


Fig. 2. — The course of induced hyperglycemia in *T. montandoni*, *T. alpestris* and *T. vulgaris*.

T. montandoni, in which the action of the following insulin doses was investigated: 0.5, 1 and 10 UI/kg b.w. In *T. alpestris* only the action of 1 UI/kg insulin dose was examined. In both species of *Triturus* this dose had a clear hypoglycemic effect (Table 3, Fig. 3).

Table 3

Action of insulin upon glycemia in <i>T. montandoni</i> and <i>T. alpestris</i>									
Item	Species	Dose UI/kg	Glycemia mg/100 ml						
			0	3	9	17	24	48	
1	<i>T. montandoni</i>	physiological saline	71	74				70	
2			95	74				80	
3			96	86				94	
4			100	90				112	
5			113	96				114	
M±Sm %			95±6.80 100	83±3.79 86.31			94±8.46 98.95		
1	<i>T. montandoni</i>	0.5	71	69	49		45	75	
2			95	73	73		50	80	
3			96	75	56		51	90	
4			100	72	60		54	70	
5			113						
M±Sm %			95±6.80 100	72±1.25 75.79	60±1.6 63.31		50±1.8 52.63	80±4.19	
1	<i>T. montandoni</i>	1	75	43	43	40	45		
2			81	55	58	53	53		
3			80	65	59	58	54		
4			100	66	61	72	59		
5			112	98	68	—	—		
M±Sm %			90±7.03 100	65±9.1 72.22	58±6.6 64.4	56±6.6 62.2	53±2.66 58.8		
1	<i>T. montandoni</i>	10	71	35	47		57		
2			95	46	50		67	43	
3			96	49	56		70	61	
4			100	66	68		70	68	
5			113	—	—		—	58	
M±Sm %			95±6.80 100	49±6.4 51.58	55±4.80 57.89		67±3.63 70.53	57±5.2 60.00	
1	<i>T. alpestris</i>	1	83	60	61	43	69		
2			63	50	45	40	45		
3			86	52	64	39	45		
4			88	55	57	42	53		
M±Sm %			80±5.7 100	54±2.1 67.5	56±4.1 70.0	44±2.4 55.0	53±5.6 66.2		

In *T. montandoni*, even after 0.5 UI insulin/kg, a significant decrease in glycemic values was produced (Table 3). In the same species, the 10 UI/kg dose induced signs of insulin shock manifested by the loss of movement coordination capacity, and even by convulsions.

The daily and repeated administration of small doses of insulin (1 UI/kg) has likewise determined, already after 3–4 injections, shock symptoms in both *T. montandoni* and *T. alpestris*, which points out to a marked sensitivity of these species to the action of insulin.

THE ACTION OF ADRENALIN

The action of three doses of adrenalin, of 10, 50 and 500 µg/kg b.w., was investigated. Both species presented an evident hyperglycemic reactivity to adrenalin.

The sensitivity limit to adrenalin was situated around the dose of 10 µg/kg (Fig. 4), which induced a slight increase in glycemia. The increase in the injected dose of hormone led to the intensification of the hyperglycemic response. This was characterized by a maximum in the first 3 hours. After 24 hours glycemia reverted to normal level (Fig. 4).

DISCUSSION OF RESULTS

One of the first findings of our investigations on *T. alpestris* and *T. montandoni* is the existence of some much higher glycemic values in these two species of *Triturus* than those indicated by Wurster and Miller [9] for *T. torosus* (25 ± 0.73 mg/100 ml), and than the values found by us in *T. vulgaris* (54 ± 4 mg) in the reproduction season. They are close to the values given by Baskovici [2] for *T. cristatus* (84 ± 6 mg) and by Walker [8] for a species belonging to another family of urodels, namely for *Necturus* (35–105 mg/100 ml).

The cause of these specific differences of the glycemic level is difficult to ascertain. They are only partially due to the different methods by which glycemia was dosed (Hagedorn-Jensen's in our and Baskovici's researches and Somogyi-Nelson's in Wurster's experiments respectively).

Wurster and Miller [7], [9] have correlated the low level in *T. torosus* to the absence of glucagon- α -producing cells from the pancreas of this species. According to the views of these authors, the high

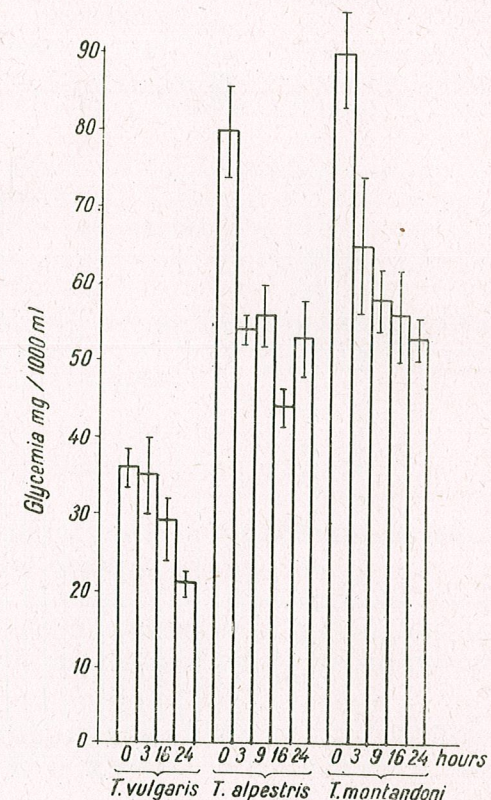


Fig. 3. — Hypoglycemic action of 1 IU insulin/kg b.w. in newts.

glycemic values would be correlated, on the contrary, to a content rich in *alpha* cells, as for instance in lizards and birds.

In the pancreatic islets of *T. alpestris* and *T. montandoni* most of the cells are of the *beta* type, but at the periphery of the islets there are

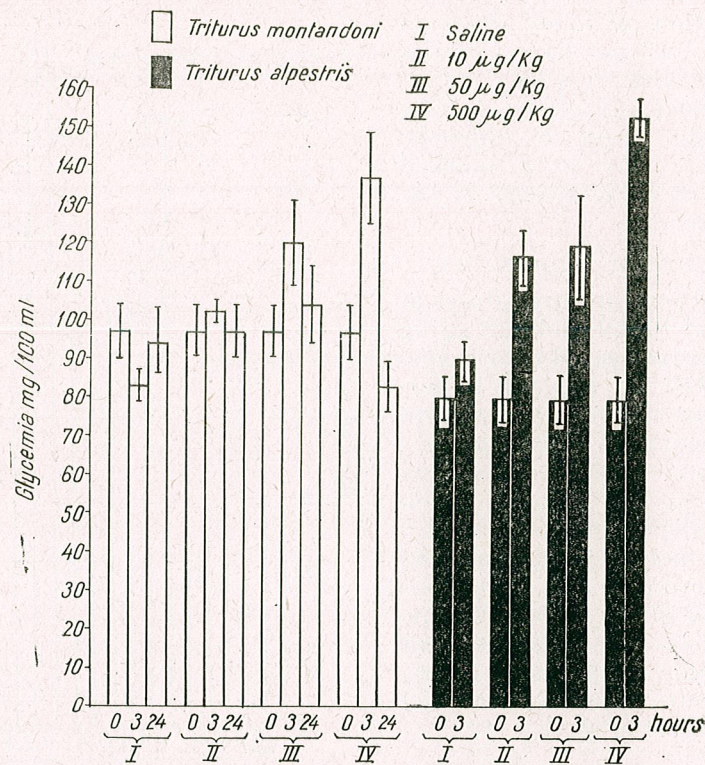


Fig. 4. — The action of adrenalin on glycemia in *T. montandoni* and *T. alpestris*.

also cells with a staining characteristic of cells capable of producing glucagon (Epple [3], and Trandaburu and C. Matei (researches unpublished as yet)).

Probably that other factors as well, season, nutritional conditions, factors connected to the ecology of the different species, play a role in determining these specific glycemic differences.

The investigation of glycemic modifications under the influence of glucose, insulin or adrenalin administration has rendered evident the existence of certain glycoregulating mechanisms which are fairly efficient in these two species of *Triturus*. The presence of such mechanisms contribute, to a certain extent, to the slow diminution of glycemia in the species during inanition. The phenomenon was likewise observed in other species of amphibians [1], [6], [7]. It can also be correlated to a lower energetic consumption in animals kept in captivity, in inanition, as well as to the possibility of utilizing other energetic sources.

The two species tolerate large quantities of glucose (1 g/kg), which they metabolize rapidly, in about 6 hours. The hypoglycemic values found after 24 hours from glucose administration show that the solving of the induced hyperglycemic condition was made with the participation of the insulinic glycoregulating mechanism.

As a matter of fact both species of *Triturus* are very sensitive to small doses of insulin, 0.5–1 UI/kg, which administered repeatedly induce convulsions. So far, the limit of sensitivity to insulin in urodels has not been established.

In *T. torosus*, Wurster and Miller [9] have administered up to the dose of 10 UI/kg, while in *T. cristatus*, Baskovici [2] has induced convulsions by using very large doses of insulin (75–188 UI/kg). The smallest dose of insulin tried by us on *T. vulgaris* was of 1 UI/kg [4].

The reactivity to adrenalin of the two species was likewise very marked. As in other species of amphibians [4], [5] a hyperglycemic response occurred already after 10 µg adrenalin/kg.

CONCLUSIONS

1. *Triturus montandoni* and *Triturus alpestris* present high glycemic values (around 100 mg glucose/100 ml blood).
2. In the reproduction period, glycemia was higher in males than in females, namely 96 ± 3.50 mg/100 ml as against 85 ± 3.27 mg/100 ml in *T. alpestris* and 105 ± 3.18 mg/100 ml as against 93 ± 4.44 mg/100 ml in *T. montandoni*.
3. Glycemia diminishes very slowly during inanition. After 20 days of inanition; the decrease in the glycemic values had but a relative significance.
4. Glucose administration (1 g/kg) induced a state of hyperglycemia, which was solved fairly quickly, in some 6 hours.
5. Both species have a marked sensitivity to insulin. The limit of this sensitivity corresponds to the dose of 0.5 UI/kg.
6. The minimum effective adrenalin dose was of 10 µg/kg.
7. The slow diminution of glycemic level during inanition, the possibility of the rapid solution of induced hyperglycemia, as well as the marked sensitivity to hyper- and hypoglycemic hormones show that the two species are provided with fairly efficient glyco-regulating mechanisms.

REFERENCES

1. APOSTOL GH., MOTELICĂ I., Com. Acad. R. P. R., 1962, 12, 3, 335–339.
2. BASKOVICI B. L., J. evol. bioch. fiziol., 1966, II, 6, 567–579.
3. EPPLE A., Gen. Comp. Endocrin., 1966, 7, 2, 207–214.

4. MATEI-VLĂDESCU C., Rev. Roum. Biol., Zool., 1965, **10**, 3, 165—169.
5. — Rev. Roum. Biol., Zool., 1966, **11**, 4, 309—314.
6. — Doctorial thesis. Cluj, 1968.
7. MILLER R. M., *Comparative Physiology of Carbohydrate Metabolism in Heterothermic Animals*, Washington, 1961, pp. 125—147.
8. WALKER M. A., HUDSON L. C., Amer. J. Physiol., 1937, **118**, 130.
9. WURSTER H. D., MILLER M. R., Comp. Biochem. Physiol., 1961, **1**, 2, 101—109.

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EFFET DU GLUCOSE SUR L'ACTIVITÉ DES ÎLOTS DE LANGERHANS CHEZ QUELQUES ESPÈCES DE VERTÉBRÉS INFÉRIEURS (POISSONS ET AMPHIBIENS)

PAR

T. TRANDABURU

The cytological modifications of the endocrine pancreas in *Cyprinus carpio*, *Triturus vulgaris*, *T. alpestris*, *T. montandoni* and *Rana ridibunda* were studied under the influence of induced hyperglycemia by administration of glucose. The glycemia was determined by Hagedorn-Jensen method.

The treatments determine evident changes in the aspect of beta cells (hyperplasia, degranulation, vacuolation and sometimes glycogen depositing), according to the quantity of glucose administered, to the duration of the treatment and the systematic group of the studied species.

As a whole, the susceptibility of the insulin-secretory elements appear more increased in carp and urodeles than in frogs.

C'est Laguesse [7] et Diamare (cité par [11]) qui ont signalé pour la première fois la présence des îlots pancréatiques chez les Poissons et respectivement chez les Amphibiens. Leur étude histologique et physiologique a été ultérieurement entreprise sur de nombreuses espèces de Poissons [2], [6], [13], Urodèles (Fischer, 1912; Kollosow, 1927; Adams et Word, 1936, cités par [9] et [11]) et Anoures (Saguchi, 1921; Hirata, 1924; De Robertis et Primavesi, 1939, cités par [1] et [11]).

De l'ensemble de ces recherches ressort l'existence, dans le pancréas endocrine des Vertébrés inférieurs, de plusieurs types de cellules, en un nombre différant en fonction de l'espèce. De plus, leur rôle physiologique présente beaucoup d'aspects inconnus.

Afin d'étudier le comportement de ces cellules par rapport à la régulation glycémique, nous nous sommes proposé d'observer leurs variations morphologiques consécutives à l'hyperglycémie provoquée par administration de glucose.

MATÉRIEL ET MÉTHODE

On a expérimenté sur les espèces suivantes : *Cyprinus carpio*, *Triturus vulgaris*, *T. montandoni*, *T. alpestris* et *Rana ridibunda*. Les animaux ont été maintenus au laboratoire à une température de 17–22°C. On a administré le glucose à 6,5% dans du sérum physiologique, par injections quotidiennes, intra-abdominales chez les Poissons et les Urodèles et dans les sacs lymphatiques dorsaux chez les Grenouilles. Le sang a été prélevé sur du fluorure de calcium après décapitation des animaux. Pour les Tritons on a obtenu la quantité de sang nécessaire à un seul dosage à partir de 2–3 individus. La glycémie a été déterminée selon la méthode de Hagedorn-Jensen, 20 à 24 heures après la cessation du traitement ; pour *T. montandoni* et *T. alpestris*, 2 à 3 heures depuis la dernière injection.

Chez les Tritons et les Grenouilles on a prélevé le pancréas ; chez les Poissons des fragments du mésentère de l'intestin antérieur et de la masse hépatique contiguë au canal biliaire. Le tissu a été fixé au Bouin, Bouin-Hollande, Helly et Römeis, inclus en paraffine et sectionné à 5 μ . On a utilisé des colorations classiques : chrome-hématoxyline-phloxine (Gömöri, 1941), azan (Bloom, 1931), para-aldéhyde-fuchsine (Scott et Clayton, 1935), PTAH (Mallory, 1900) et PAS-dimedon-McManus.

RÉSULTATS

Chez la Carpe, le pancréas endocrine apparaît normalement sous forme d'îlots ovales de dimensions variables, inclus dans les lanières du pancréas exocrine. On les rencontre ordinairement près de la vésicule biliaire, du canal bilio-pancréatique et dans le mésentère de l'intestin antérieur [13]. Les îlots sont délimités par une capsule conjonctive et contiennent des cordons cellulaires parsemés de capillaires et de terminaisons nerveuses.

Les cellules insulaires se colorent différemment, selon la technique utilisée et l'on peut distinguer deux types principaux : A et B.

Chez les Tritons, les îlots sont répandus dans la masse du pancréas exocrine, en étroite relation avec le tissu acineux.

Le cytoplasme des cellules endocrines contient de fins granules, uniformément répandus et de moindres dimensions que les granules de zymogène. Les cellules B prévalent dans les îlots des Tritons (fig. 2). On distingue plus rarement à leur périphérie des cellules à coloration semblable à celle du type A.

Chez les Anoures (*Rana ridibunda*), les îlots contiennent des cellules A et B en proportion pratiquement égale. Ces cellules sont de plus grande taille que celles du pancréas exocrine et présentent des granules spécifiques. De plus, les cellules A sont plus grandes que les cellules B. A côté des îlots de grandes dimensions apparaissent souvent dans le champ microscopique des groupes ne contenant que 4–5 cellules. En ce cas, plus encore que chez les Poissons, on observe une disposition périphérique des cordons de cellules A par rapport aux cellules B (fig. 6).

L'administration de glucose, durant des périodes et en doses variables, a déterminé chez toutes les espèces des hyperglycémies évidentes (tabl.1).

L'image morphologique du pancréas endocrine subit à son tour des transformations.

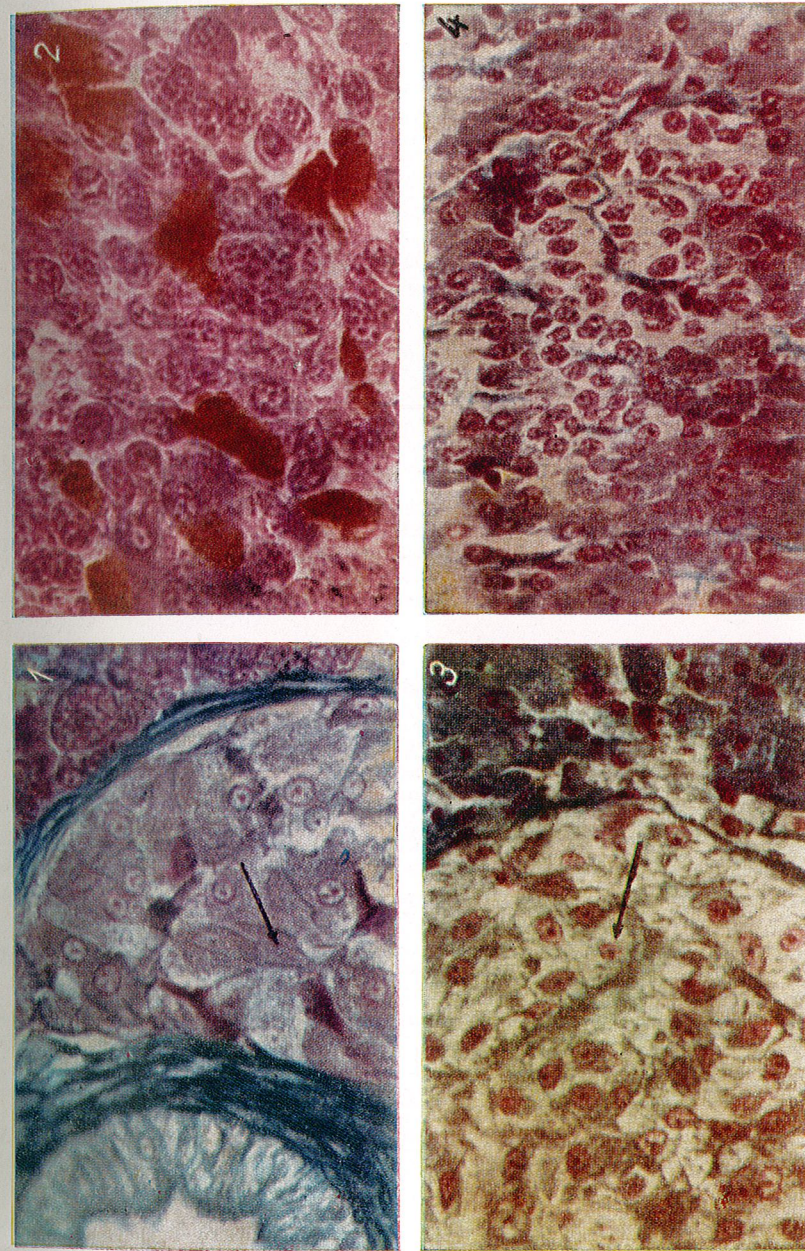


PLANCHE I. 1. Partie d'un îlot de Langerhans chez *Cyprinus carpio*. On distingue les cellules B rouges (flèche) contenant des granules d'insuline, la capsule conjonctive, un fragment du conduit pancréatique (à gauche) et du pancréas exocrine (à droite). Fixation au Bouin-Hollande, coloration azan (90 \times 2,5). 2. Îlot chez *Triturus montandoni*. On distingue parallèlement les granules spécifiques des cellules B (en rouge). Fixation au Bouin-Hollande, coloration azan (90 \times 2,5). 3. Îlot chez *Cyprinus carpio* ; traitement par du glucose à raison de 3g/kg durant 7 jours. On observe la dégénérescence des cellules B. Fixation au Bouin-Hollande, coloration azan (90 \times 2,5). 4. Pancréas endocrine chez *Triturus montandoni* contenant des cellules B vacuolisées (glucose à raison de 1 g/kg durant 6 jours). Fixation au Bouin-Hollande, coloration azan (45 \times 2,5).

Tableau 1

La glycémie normale et provoquée chez les espèces étudiées

Espèce	Substance	Dose g/kg	Durée du traitement (jours)	Glycémie moyenne (mg %)	Obs.
<i>Cyprinus carpio</i>	glucose	témoin	—	119	71 mg % (12)
		0,5	28	98	
		1,0	14	109	
		2,0	7	249	
		3,0	7	291	
<i>Triturus vulgaris</i>	glucose	témoin	—	43	41 mg % (9)
		1,0	7	83	
		2,0	8	94	
<i>Triturus alpestris</i>	glucose	témoin	—	85	
		1,0	6	151	
<i>Triturus montandoni</i>	glucose	témoin	—	91	
		1,0	6	219	
<i>Rana ridibunda</i>	glucose	témoin	—	40	<i>Glycosurie</i> 233 initiale 344 finale
		0,5	28	47	
		2,0	7	43	
		3,0	7	37 initiale	
		3,0	7	45 finale	

Après une administration chronique chez les Poissons (0,5 g/kg durant 28 jours), les îlots apparaissent faiblement atteints. Du reste, la moyenne des valeurs glycémiques n'indique pas non plus un épuisement de leur potentiel de sécrétion. En revanche, les doses plus fortes de glucose (1, 2 et 3 g/kg), quoique en des traitements de plus courte durée, provoquent des changements physiologiques plus profonds qui font présumer un dérèglement du mécanisme sécrétoire de l'insuline et un épuisement des cellules B. Morphologiquement, ces phénomènes se traduisent par une dégranulation, une forte vacuolisation, la perte des contours cellulaires (fig. 3), ainsi que par « l'infiltration de glycogène » (fig. 7). Les cellules A ne paraissent pas être influencées par ces traitements (fig. 5).

Le glucose produit une dégranulation avancée et une vacuolisation des cellules B chez toutes les espèces de Tritons étudiées, sans modifier pour cela de manière importante les dimensions cellulaires (fig. 4). La réaction au PAS est négative.

Le traitement chronique appliqué aux Anoures (0,5 g glucose par kg, durant 28 jours) a produit une évidente augmentation du nombre et des dimensions des îlots de Langerhans. Les cellules B ont subi une hypertrophie manifeste, tout en maintenant une granulation bien visible, signe d'après nous d'un état hyperfonctionnel. Les doses plus fortes de glucose, répétées, ont provoqué une dégranulation et une vacuolisation modérée des cellules B. On n'a pu que rarement mettre en évidence le glycogène dans les îlots, quoique les cellules de l'épithélium des conduits pancréatiques présentassent quelquefois une réaction positive au PAS.

DISCUSSIONS

La plupart des chercheurs s'accordent pour décrire l'existence de deux types principaux de cellules dans les îlots pancréatiques normaux des Poissons osseux [3], [14] : les cellules A et B. Leur rapport numérique est caractéristique pour l'espèce et présente des variations saisonnières [14]. D'autres ont trouvé plusieurs types de cellules insulaires (Bensley et Bloom, 1931 — cellules C et D ; Thomas, 1937 — cellules E, cités par [14]), mais à caractères cytologiques mal définis. Nous sommes tentés de les considérer, ainsi que Schätzle, comme représentant des formes de transition vers l'une des deux formes de cellules mentionnées.

Le pancréas endocrine des Urodèles est composé, en grande proportion (Fischer, 1912 ; Kollosoy, 1927, cités par [11]) sinon exclusivement [16], de cellules *bêta*, ce qui expliquerait aussi, selon les derniers auteurs, le bas niveau glycémique que présentent certaines espèces (*Triturus torosus*). Nos observations nous ont montré l'existence, à la périphérie des îlots, de certaines cellules, il est vrai en petit nombre, qui présentent un aspect quelque peu différent de celui des cellules B. Selon Kollosoy, ces cellules feraient la transition de l'élément exocrinien vers l'élément endocrinien.

Quant à la composition cellulaire des îlots chez les Anoures, les uns acceptent l'existence de deux types (Hirato, 1934, chez *Rana japonica* ; De Robertis et Primavesi, 1939, chez *Bufo arenarum*, cités par [11]). D'autres décrivent 5 catégories de cellules qu'ils considèrent interchangeables (Saguchi, 1921, cité par [11]), tandis que Barrington, dans une étude plus récente sur *Rana temporaria*, attribue la coloration variable des cellules endocriniennes aux différentes phases sécrétoires des cellules B. Les techniques que nous avons employées nous portent à considérer que le pancréas endocrine chez *Rana ridibunda* contient deux principales catégories de cellules, A et B.

Les modifications cytologiques constatées par nous chez les Poissons, les Urodèles et les Anoures par suite de l'administration chronique de glucose représentent la conséquence de certaines perturbations du métabolisme glucidique, de la sécrétion et de la libération de l'insuline. Les recherches de Grodski et Bennett [5], entre autres, ont montré que le glucose agit en premier lieu sur les mécanismes de libération de l'insuline de dépôt et non pas nécessairement sur l'insulinogénèse. De plus, la haute glycosurie des Anoures (tabl. 1) indique la possibilité de ces poikilothermes de contrecarrer l'hyperglycémie.

La mise en réserve du glycogène, soit dans les cellules épithéliales du conduit pancréatique, soit dans les cellules B, apparaît souvent en cas de diabète sévère prolongé chez l'Homme et chez d'autres Mammifères. Selon Lazarus et Wolk [8], ce phénomène n'est pas responsable des différentes formes de métadiabète et ne peut être mis en relation avec les changements dégénératifs subis par les éléments insulinogènes.

CONCLUSIONS

Le glucose provoque chez les espèces étudiées, en fonction de la dose et de la durée du traitement, des troubles du métabolisme glucidique, avec répercussions sur le pancréas endocrine. Ainsi, on constate :

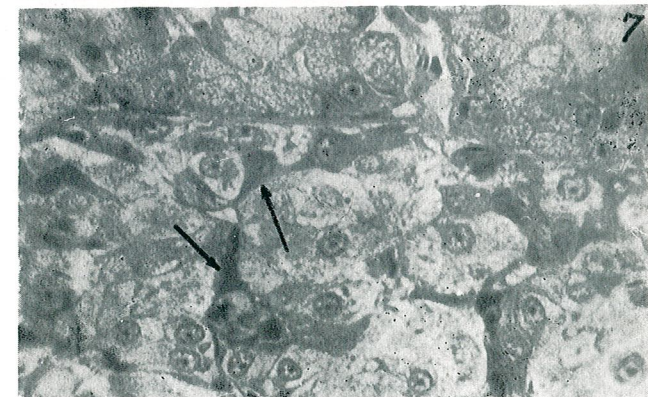
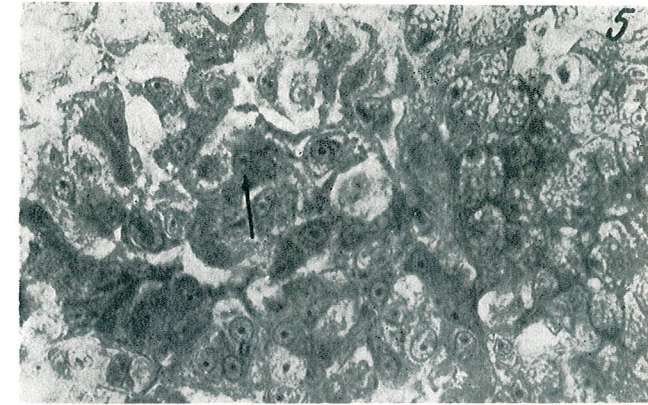


PLANCHE II. 5, Les cellules A chez *Cyprinus carpio* sont colorées de manière élective par le PTAH en bleu-mauve (flèche) et ne paraissent pas être influencées par le glucose (1 g/kg durant 7 jours). Fixation au Helly, coloration PTAH (90×2,5). 6, Îlot chez *Rana ridibunda*. Les cellules A sont colorées par le PTAH et ont une localisation périphérique. Les cellules B sont indiquées par la flèche (glucose 1 g/kg durant 7 jours). Fixation au Helly, coloration PTAH (45×2,5). 7, Partie d'un îlot chez *Cyprinus carpio*. On remarque la mise en réserve du glycogène (flèches). Traitement par du glucose à raison de 3 g/kg durant 7 jours. Fixation au Bouin, coloration PAS-dimedon-McManus (90×2,5).

- la dégranulation, la vacuolisation et la dégénérescence des cellules B;
- l'infiltration du glycogène (chez les Poissons et parfois chez les Grenouilles);
- l'hyperplasie des îlots et des cellules B (chez les Grenouilles).

BIBLIOGRAPHIE

1. BARRINGTON E. J., Quart. J. Microscop. Sci., 1951, **92**, 205.
2. CASTALDI S., Bull. Assoc. Anat., 1926, **1**, 1952.
3. FALKMER S., Acta Endocrinol., 1961, **37**, suppl. 59, 7.
4. GORBMAN A., *A Textbook of Comparative Endocrinology*, Academic Press, N. Y., 1960, 203.
5. GRODSKY M. G., BENNETT L., Proc. Soc. Expt. Biol. Med., 1963, **114**, 769.
6. KEIL O., Anat. Anz., 1917, **250**, 5, 24.
7. LAGUESSE F., C. R. Acad. Sci. Paris, 1891, **112**, 440.
8. LAZARUS S. S., VOLK B. W., Arch. Pathol., 1958, **66**, 59.
9. MATEI-VLĂDESCU CONSTANȚA, Rev. Roum. Biol.—Zool., 1965, **10**, 3, 165.
10. MILLER M. R., WURSTER H. D., *Comparative Endocrinology*, Academic Press, N. Y., 1959, 668.
11. MOORE J. A., *Physiology of Amphibia*, Academic Press, N. Y., 1964, 394.
12. MOTELICĂ I., *Contribuții la studiul glicemiei peștilor*. (Thèse), 1965, Cluj.
13. ȘANTA VALERIA, POLLINGER UȚA, Anal. Inst. Cerc. Pisc., 1960, **1**, 203.
14. SCHÄTZLE W., Ann. Univ. Saraviensis, 1954, **1**, 53.
15. SCHIEBLER TH., SCHIESLER S., J. Histol. Cytochem., 1960, **8**, 312.
16. WURSTER H. D., MILLER M. R., Comp. Biochem. Physiol., 1960, **1**, 2, 101.

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