Experimental study on the accumulation of radioactive substances by ichthyoneuston of the Black Sea

by

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The eggs of many fishes are pelagic and they develop in the water layer near the surface — in hyponeuston [ZAITSEV, 1961], where together with other components of plankton they can accumulate radioactive substances from their environment [ZAITSEV & POLIKARPOV, 1964; POLIKARPOV & GAMEZO, 1966].

The study of the concentration of radionuclides by the developing sea fish eggs is of interest from several points of view. They are :

1. Concentrating the radioactive substances eggs create hightened sources of ionizing radiation and the radiation injury of the developing embryos might occur at lower concentrations of radionuclides than is expected. To estimate the radiation dose received by the eggs during their development is possible only by determination of the concentration factors for different elements.

2. Radioisotopes of some elements are assimilated by developing embryos and enter the biochemical components of the cells. One may follow during embryogenesis the transport and the chain of chemical transformations of these elements by studying the accumulation of their radioisotopes. In this way some microconstituents which cannot be investigated by ordinary chemical and biochemical methods can be studied also.

3. The problem of the preservation of a radioactive tag in different stages of ontogenetic development can be solved with studies of the accumulation mechanisms of radionuclides by eggs and pre-larvae.

In our experiments the incorporation of C^{14}, P^{35}, S^{35}, Mn^{54}, Fe^{59}, Co^{60}, Sr^{89}, Sr^{90}, Y^{90}, Y^{91}, Ru^{106}, Cs^{137}, Ce^{144} and W^{185} in the pelagic eggs of the following Black Sea fish species was studied: *Trachurus mediterraneus ponticus* Al., *Engraulis encrasicholus ponticus* Alex., *Rhombus maeoticus* Pall., *Scorpaena porcus* L., *Uranoscopus scaber* L., *Mullus barbatus ponticus* Ess., *Serranus scriba* L.

Methods used in this research, described by IVANOV [1965*a*, 1965*b*] consisted of : 1. preparation of radioisotope working solutions; 2. incubation of eggs and pre-larvae in sea water contaminated by radioisotopes; 3. co!lection of water, egg and pre-larvae samples and their radiometry; 4. calculation of concentration factors (C.F. = radioactivity in g of eggs/radioactivity in ml of water).

The morphology and ecology of the studied eggs is similar. The eggs are ballshaped or slightly eliptic, with diameter from 0.8 to 1.5 mm (Uranoscopus eggs – 3 mm). Their surface is transparent and rather thin. At optimal temperature the embryogenesis lasts 2 - 5 days. The eggs are spawned not individually.

The average C.F. obtained in our experiments are isted in Table 1. One can see that the C.F. for the same radioisotopes are rather close in different species.

The C.F. of Y^{90}, Ce^{144} and Fe^{59} are the highest and therefore these radioisotopes should be considered as the most dangerous from radiobiological point of view.

From an equilibrium solution of Sr^{90}-Y^{90}, the Y^{90} accumulated by eggs and embryos can give radiation which is by 1-2 order of magnitudes higher than that originating from Sr^{90}.

Rapp. Comm. int. Mer Médit., **20**, 4, pp. 763-765 (1972).

Analysing the C.F. for the eggs and pre-larvae one can make conclusions concerning the localization and the way of assimilation of radionuclides. For example, the difference in the C.F. for Ce^{144} in eggs and pre-larvae makes it doubtless that practically all the accumulated Ce^{144} is localised on the surface of the eggs. Quite the reverse is true for P^{32}, Sr^{89}, Sr^{90} and Cs^{137}. Pre-larvae havin ghigher C.F. than the eggs indicate an accumulation of radionuclides by developing embryos.

While some radionuclides are very actively accumulated by the developing eggs, others are only adsorbed to their surface independently from the psysiological processes in the eggs. For instance Y^{91} showed practically the same C.F. in unfertilised and already decomposing eggs of Rhombus (51) as in the normally developing eggs (44).

Among the investigated biogenic elements S^{35} is accumulated the least. Its concentration in the developing embryo was below its concentration in the environment.

C^{14} is accumulated by the developing eggs. According to SHEHANOVA [1967] in the eggs of *Misgurnus fossilus* 20-30 p.100of the accumulated C^{14} was adsorbed to the surface, 30 p. 100 in perivitell ine and only 10 p. 100 in the embryo.

As it was shown already earlier [ZESENKO & IVANOV, 1966; WHEHANOVA, 1967] P^{32} is actively accumulated by eggs and pre-larvae.

The surface of the eggs can be considered as an essential barrier for many radionuclides. Its protecting effect may be intensified with other ecological adaptations, as is for instance the mucous layer covering the eggs of scorpaena which plays an important role in Sr^{89} accumulation [POLIKARPOV & GAMEZO, 1966]. In our experiments C^{14} and Y^{91} were practically not accumulated by Sorpaena eggs as long as they have been in mucous coating.

Data from Table 1 indicate that some of the Y^{90}, Y^{91} and Ce^{144} adsorbed on the surface is penetrating into the eggs.

The reported results show that much more research is needed to clarify the biological consequences of the radionuclide accumulation by ichthyoneuston and ichthyoplankton. In this research the C.F. calculated for the whole eggs cannot be considered as a sufficient indicator for the radioisotope assimilation, because most of the radioisotopes — especially the rare earths and yttrium — concentrate by absorption locally on the eggs' surface.

Biogenic elements might be used for very efficient tagging of the developing embryos, because their radionuclides are easily bound in the embryos' biomolecules.

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Table 1. — Concentration factors for different radionuclides in the eggs before pre-larval stage and in the first pre-larval stage.

Radionuclide	Sample	Concentration factor
C^{14}	eggs	27.5
P^{32}	eggs	6.7
	pre-larvae	14.4
S^{35}	eggs	1.0
	pre-larvae	0.6
Mn^{54}	eggs	3.3
	pre-larvae	1.0
Fe^{59}	eggs	152.0
Co^{60}	eggs	3.3
Sr^{89}	eggs	1.3
	pre-larvae	1.5
Sr^{90}	eggs	1.0
	pre-larvae	1.2
Y^{90}	eggs	108.0
	pre-larvae	1.6
Ru^{106}	eggs	12.0
	pre-larvae	3.6
Cs^{137}	eggs	8.9
	pre-larvae	9.8
Ce^{144}	eggs	401.5
	pre-larvae	2.9
W^{185}	eggs	9.4
	pre-larvae	0.9