Morphological Characterization of the Stomach of Field-Mice Living in Ecologically Unfavorable Regions

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Translated from *Byulleten' Eksperimental'noi Biologii i Meditsiny*, Vol. 121, No. 6, pp. 711-715, June, 1996
Original article submitted November 14, 1995

The gastric wall of field-mice living in three ecologically unfavorable regions of the Altai is studied. A key role of dystrophic and atrophic changes in the mucous and keratinized zones of the gastric lining and the absence of a pronounced inflammatory-cellular component are demonstrated. It is noted that numerous ecological factors modulating each other's effects in time and intensity hamper the interpretation of changes occurring in the biosystems where they operate.

Key Words: *radioactive and anthropogenic contamination; wild rodents; gastric epithelium; morphology; morphometry*

The long-term consequences of repeated exposure to low doses of ionizing radiation have not been studied in sufficient detail [10]. The steady increase in environmental pollution with industrial toxins has prompted an investigation into the combined effects of radionuclides and other anthropogenic factors on ecosystems [14]. The state of "borderline" tissues is an integral index which reflects the adaptive reserves of the organism in habitats transformed by the hand of man [7-9,11]. The epithelium of rapidly renewed gastric mucosa, which performs a number of specific functions [13] and is an "entryway" for xenobiotics, is a convenient model for investigating these reserves.

The aim of the present study was to compare structural changes occurring in the gastric mucosa of field-mice from three ecologically contrasting Altai regions using light microscopy and morphostereological analysis.

MATERIALS AND METHODS

Field-mice (*Microtus arvalis*) were chosen because they have an expanded natural habitat, hardly not migrate, and live in the upper layers of the soil [3], where contaminants are accumulated. Seventy-two mice from three ecologically contrasting Altai regions were studied. Group 1 mice were caught in the Uglovskoe region (radioactive contamination caused by tests in the Semipalatinsk nuclear test area carried out from 1949 till 1962) [4]. Group 2 mice were from the Lokot' region contaminated by radionuclides and heavy metals of both natural and technogenic origin as a result of mining [14]. Group 3 animals were from the Tyumentsevo region, which is considered to be free of radioactive contamination [12], but has high levels of soil pollution due to intensive irrigation and agriculture [14].

Stomach specimens cut from the cardiofundic, pyloric, and bottom glandular regions [6] were pooled into three groups and fixed with 10% neutral Formalin, embedded in paraffin, and stained with hematoxylin and eosin in combination with the Perls reaction, after Van Gieson, and with Schiff reagent.

Morphometric and stereological analysis of the gastric mucosa was performed using semithin longitudinal sections stained with azure III and Schiff reagent. The thickness of the mucosa as well as the height of the surface epithelium [1] and of the rugae were measured. The volume and surface densities of gastric pits and capillaries were calculated as pri-

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mary stereological parameters using a multipurpose test system. The surface-volume ratio of these structures was then calculated. Secondary stereological parameters (the surface-volume and volume ratio of capillaries and surface epithelium) were calculated. The data were analyzed using statistical methods.

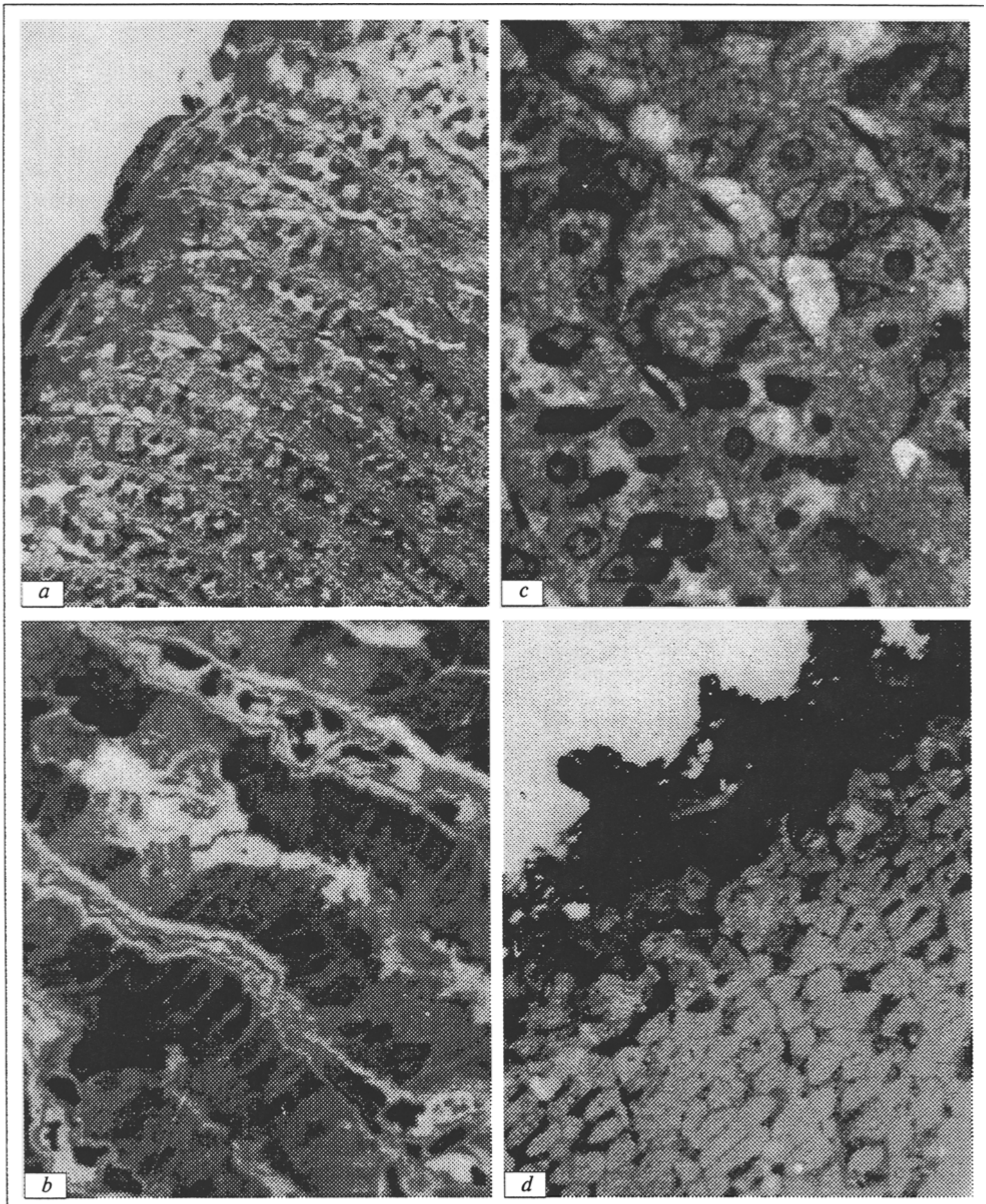

Fig. 1. Light microscopy of field—mouse gastric mucosa. Semithin sections. Azure II and Schiff reagent staining. *a)* flattening of mucosal relief, × 200; *b)* deepening and deformation of pits, dystrophy of epithelial cells, × 600. *c)* glandular zone: accumulation of secretory granules in the chief cells, × 800; *d)* polymorphism of the rugae, × 250.

RESULTS

The presence of two zones in the gastric lining is a specific feature of the field-mouse [15,16]. The first zone is represented by stratified squamous keratinized epithelium which predominates in the fundic and pyloric regions. The second zone is represented by true mucosa with glandular epithelium.

In the majority of group 1 mice, flattening of the luminal relief was revealed by light microscopy: the epithelium was reduced to 2-3 layers of flattened cells and its stratification disappeared.

Dystrophic changes in the surface epithelium of the glandular zone were observed in most cases. Enhanced desquamation of foveolocytes occurred not only on the tops of the rugae but also on their lateral surfaces, sometimes with the formation of microerosions. The histoarchitechtonics of pits varied in a wide range: from a decrease in their number and flattening of the luminal surface relief (Fig. 1, *a*) to their deepening (Fig. 1, *b*). The height of the cells of the pit epithelium also varied: cuboidal cells predominated over flattened cells with reduced secretion. The heterochromatin content in the nucleus increased, and it was condensed along the nuclear membrane and throughout the nucleoplasm. Foci of elongated epithelial cells with spiny hyperchromatous nuclei were seen, which is consistent with the phenomenon of dysplasia.

Dystrophic changes also occurred in the glandulocytes of the bottom glands located in the neck zone. Similarly to the changes observed in chronic atrophic gastritis [2], the zone of neck mucus-producing cells was widened, leading to a decrease primarily in the number of parietal glandulocytes, which became bigger and often binuclear as a result of compensatory hypertrophy. These cells were heterogeneous in degree of maturity and in functional activity, although glandulocytes with an increased content of heterochromatin in the nuclei predominated. Mucous granules were accumulated in the chief cells.

In contrast to group 1, in group 2 the normal structure of the epithelium in the keratinized zone was often preserved, its atrophy being recorded only in 11% of animals. The pits in the mucous zone with preserved structure of surface epithelium were often deepened. All stages of the secretory cycle in the faveolocytes and the functional activity of glandular cells were preserved (Fig. 1, *c*). Atrophy of the surface epithelium with focal hyperplasia was observed in some cases.

Group 3 mice, together with epithelial atrophy in the keratinized zone, exhibited focal hypertrophy, which was often accompanied by increased lymphoid infiltration of the subepithelial stroma. Atrophy and hyperplasia of the mucous zone were recorded in 20% of cases. In most animals the thickness of the rugae was increased; sometimes they looked delicate and even ramified partly due to pronounced variations of cell height (Fig. 1, *d*).

In group 3, the functional activity of glandulocytes varied widely. The degree of chromatin condensation in the nuclei of the parietal cells of the neck and body of glands also varied.

Hemodynamic disorders in both zones occurred in all studied mice. Lymphocyte and plasma cell infiltration had the following common features: the cells were located in the subepithelial stroma of the stratified squamous keratinized epithelium and in the perivascular zone at the level of the pits and terminal regions of glands. In group 2, the infiltration was insignificant, being more pronounced in group 1. In group 3, it was diffused, and occasional neutrophils were seen.

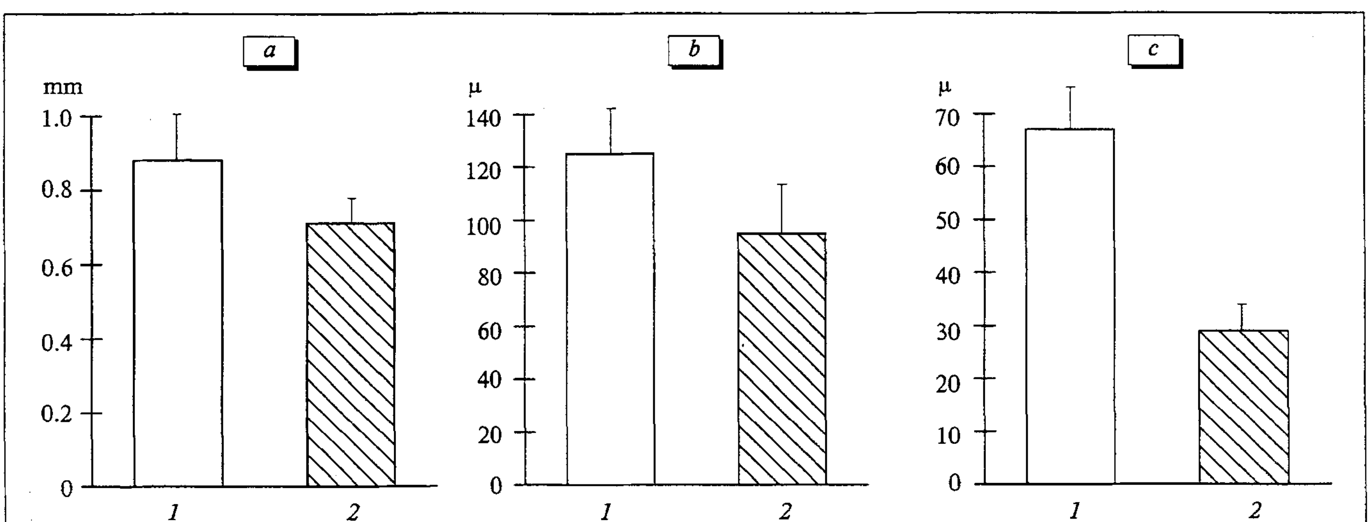

Fig. 2. Morphometric characterization of fundic mucosa of field–mice from two different regions. *a*) thickness of the mucosa; *b*) area occupied by surface epithelium; *c*) height of the rugae. The Tyumentsevo (*1*) and the Lokot' (*2*) regions of the Altai.

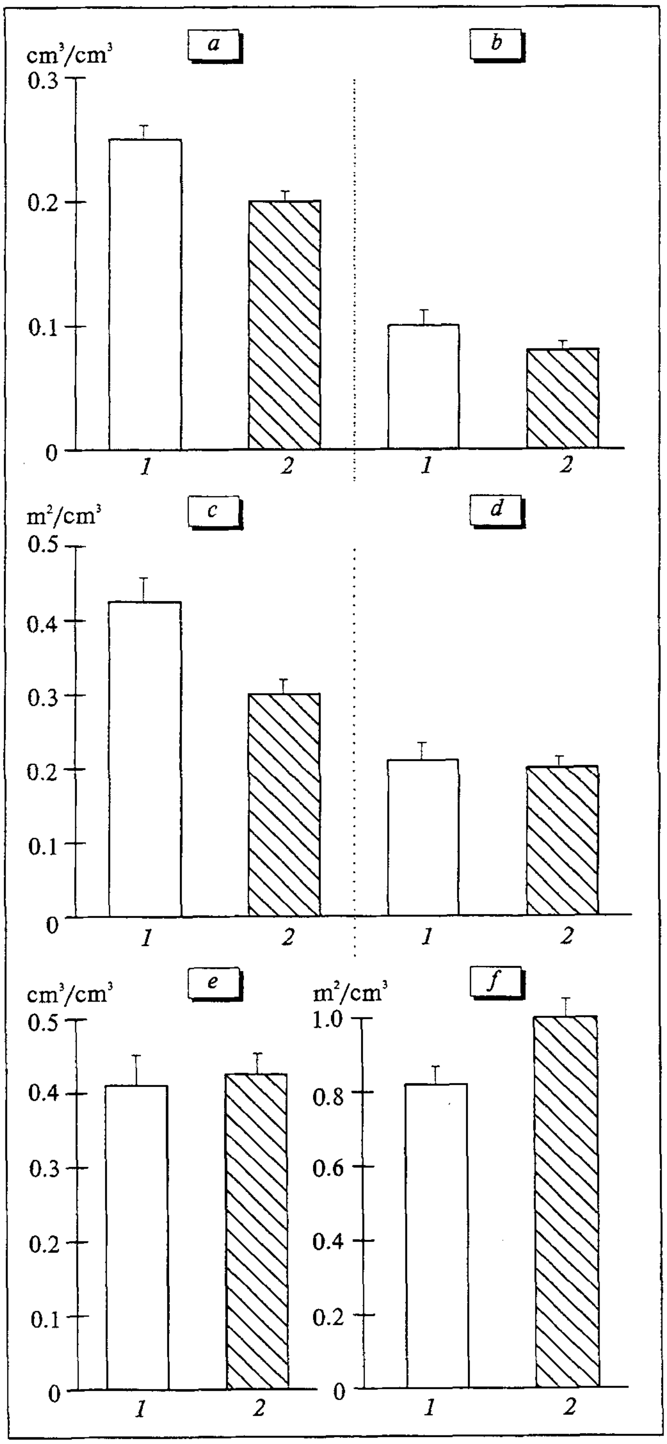

Fig. 3. Stereological analysis of the gastric mucosa of field-mice from two regions. *a*) volume density of pit surface epithelial cells; *b*) volume density of capillaries; *c*) surface density of surface epithelial cells; *d*) surface density of capillaries; *e*) volume ratio of capillaries to pit surface epithelial cells; *f*) surface-volume ratio of capillaries to pit surface epithelial cells. The Tyumentsevo (*1*) and the Lokot' (*2*) regions.

Morphometric analysis was performed in groups 2 and 3 animals, which were captured in regions with different levels of radioactive contamination (group 3 mice were from the less contaminated Tyumentsevo region). A statistically significant decrease in the thickness of the rugae and a tendency towards a decrease in the thickness of the mucosa and surface epithelium (Fig. 2) were observed in group 2 mice (the Lokot' region), which reflects the flattening of the relief of the gastric lining and indicates the dystrophic nature of the structural response. Stereological analysis (Fig. 3) showed the absence of significant differences between primary and secondary parameters.

Thus, a complex morphological investigation of the gastric lining in field-mice from three regions differing in combination of anthropogenic factors showed that nonspecific dystrophic-atrophic changes in the stratified squamous keratinized and glandular epithelia [2] without inflammatory-cellular infiltration dominate in all animals studied. The absence of any distinct relationship between these changes and the radiation dose or other ecological factors may be due to insufficient information regarding contamination of the territory, on the one hand, and to the presence of several factors modulating each other's effects in time and intensity, on the other. Presumably, under current conditions of man-induced modification of biocenoses [5] adaptive morphogenesis of the gastric lining is going on in mice, but the general features of the process depend on an increasing number of additional factors, making its interpretation much more difficult.

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