pellets were used as control pellets. In experiment 2, potassium pellets were used as control pellets.

Results. In experiment 1, 5 out of the 6 fish completing the experiment increased their preference for the sodium pellets as a result of deprivation (Figure 1). Before deprivation, 4 fish showed a stronger preference for the salt-free pellets than for the sodium pellets, 1 fish showed a stronger preference for the sodium pellets, and 1 fish ate an equal number of both types. After deprivation, 5 fish showed a stronger preference for the sodium pellets than for the salt-free pellets and only 1 showed a stronger preference for the salt-free pellets. In experiment 2, all 6 fish increased their preference for the sodium pellets as a result of deprivation (Figure 2). Before deprivation, 3 fish showed a stronger preference for the sodium pellets than for the potassium pellets, and 3 showed a stronger preference for the potassium pellets than for the sodium pellets. After deprivation, all 6 fish showed a stronger preference for the sodium pellets than for the potassium pellets.

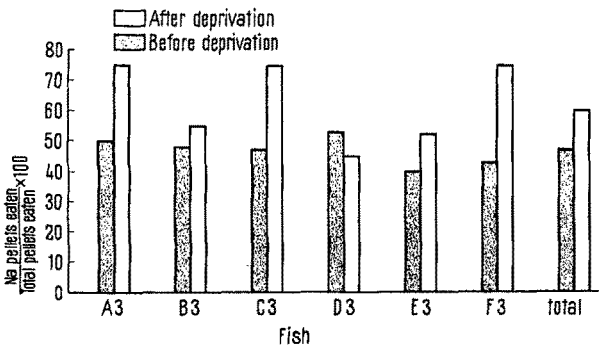

Fig. 1. Relative preference shown for sodium pellets before and after deprivation using salt-free control pellets.

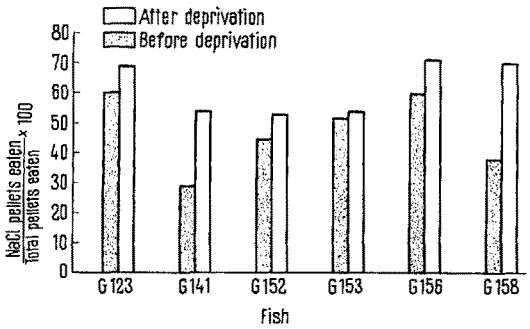

Fig. 2. Relative preference shown for sodium pellets before and after deprivation using potassium control pellets.

Conclusion. The results from experiment 1 show that goldfish increase their preference for salt-containing foods when they are kept in water with a low sodium content. The results of experiment 2 suggest that the sodium ion in the salt-containing foods is responsible for this increased preference[4].

Résumé. Les poissons rouges sentent le manque de sodium et, lorsqu'ils sont placés dans de l'eau contenant très peu de sodium, leur préférence pour les aliments contenant du sel est accrue.

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Exotoxin in Malaria Infection (*Plasmodium berghei*)

Recent investigations have shown [1,2] that large amounts of plasmodium proteins are necessary to induce protective immunity against *Plasmodium berghei*. About 5 g/kg body weight of the antigen must be injected in the course of 28 days in order to provide 80% of mice of the Swiss strain with an established immunity. This dose is much higher than the average amount of antigen needed for immunization against soluble heterologous proteins. From this we concluded that only a small part of the plasmodium acts as the specific antigen which produces the protective immunity. But it was not known whether an exotoxin, perhaps stored in the parasite or in the host cell, was responsible for the mechanisms of immunity. As the assumed exotoxin should appear in the serum after the rupture of the host cell during schizogony, the following investigations were carried out.

Methods. 5 groups (I–V) of 25 Swiss mice each were injected with different amounts of serum obtained from mice with high parasitemia (12th day post infection with *Pl. berghei*). A total of 9 injections (3 each week) were given i.p. without any adjuvants to each animal: (group I) 0.005 ml per shot (total 1.5 mg serum protein), (II) 0.01 ml (3 mg), (III) 0.1 ml (30 mg), (IV) 0.3 ml (90 mg), and (V) 0.6 ml (180 mg). 1 day after the last injection the mice were infected with about $5 \cdot 10^6$ parasites (*Pl. berghei*). 100 untreated animals kept under equal conditions (standard diet, water, room temperature) served as controls. For blood smears see Table.

Results. Surprisingly, all immunized mice developed daily-increasing parasitemia, just like the untreated animals. And like the control group, of which no animals survived the 25th day post infection, all mice of groups IV and V died at the same time. However, 2 animals (8%) of group I, 11 (44%) of group II, and 1 (4%) of group III survived this critical time. Though developing

[1] C. JERUSALEM, IInd Int. Conf. Protozool., London, 1965, p. 208.
[2] C. JERUSALEM, IX. Int. Congr. Mikrobiol., Moskau, 1966, p. 571.

Parasitemia (x) in control animals (A) and in serum-immunized Swiss mice (B)

(A) Day post infection	2	4	7	9	11	14	16	18	21	23	25	26
n	14	15	16	15	9	15	15	10	9	12	8	5
x	2.2	2.4	14.5	24.5	41.0	40.3	42.4	38.5	46.6	43.3	44.1	42.2
s_x	± 1.7	± 1.6	± 9.6	± 11.1	± 8.2	± 6.9	± 8.5	± 6.4	± 9.9	± 6.8	± 11.3	± 6.8
(B) Day post infection	14	18	22	28	32	35	37	42	46	49	51	53
n	8	5	10	10	4	9	4	9	4	9	2	9
x	45.3	67.5	65.8	79.1	78.6	74.0	51.5	26.2	17.5	4.0	6.2	1.1
s_x	± 11.1	± 5.9	± 13.4	± 8.8	± 5.5	± 13.6	± 15.1	± 13.3	± 4.9	± 3.8	± 2.4	± 0.7

heavy parasitemia, anaemia and leucocytosis, surviving mice did not look ill except for the pale colour of tail, ears and paws. Parasitemia increased continuously up to the 35th day post infection, when 80% of all erythrocytes contained one or several plasmodia. Between the 35th and 42nd day post infection parasitemia suddenly decreased, and 21 days later all animals were free of parasites.

Discussion. It is generally known that, in contrast to strain NMRI[3,4], untreated Swiss mice never survive infection with *Pl. berghei*[5-7]. Our recent experiments show spontaneous recovery from a heavy infection in Swiss mice for the first time. These results permit us to distinguish between 2 different mechanisms of immunity to malaria parasites. The course of parasitemia in mice immunized with serum from infected mice demonstrates the development of a plasmodiostatic factor which does not become effective before the 35th day post infection. These observations correspond to those obtained by previous investigations on the subject of active immunization[1] and on the influence of *p*-aminobenzoic-free diet[6,8].

However, spontaneous recovery in Swiss mice is only possible by previous immunization with serum containing a certain amount of malaria exotoxin. The antitoxin protects mice from toxic injury but has no influence on the development of the plasmodia and does not suppress parasitemia. It appears prior to plasmodiostatic factors (up to the 21st day post infection).

The immunization against malaria exotoxin was only successful with relatively small amounts of serum (3 mg protein/mouse). A higher total dose (more than 30 mg) is likely to lead to immunoblockade. Perhaps Swiss mice form little antitoxin or an early occurrence of high amounts of exotoxin induces an immunoblockade. All untreated mice die from toxic or hypoxemic[8] injury before the plasmodiostatic factors become effective. It is possible that mice of the strain NMRI, which show high resistance to *Pl. berghei*[4,7], are able to produce an antitoxin earlier or a more potent form of it.

Furthermore, the detection of a physiological action of a malaria antitoxin may help to explain some hitherto contradictory results in experimental and human malaria research. The course of the malaria infection and especially immunity reactions are mostly evaluated by the increase or decrease of parasitemia. However, though the evaluation of γ-globulins during the infection has been proved to be related to malaria[9-11], there is no correlation between the level of γ-globulins and the protective (plasmodiostatic) immunity[12-14]. Therefore it is supposed that much of the γ-globulin excited during malaria infection may be non-specific[15], or partly specific but non-protective. And only about 5% of the total[16] is the specific protective antibody[14]. SCHINDLER[13] found that, together with the increase of resistance to repeated reinfections, the amount of antibody measured by the fluorescent antibody technique decreases.

From the clinical point of view it is well known that the level of parasitemia does not correspond in every case with the clinical picture. These findings and also the contradictory results of passive immunization[17-22] may be due to the fact that different sera contain different amounts of antitoxin.

Our investigations indicate that probably a part of the so-called 'non-specific' γ-globulins[14,15] elevated during malaria infection is an antitoxin. This antitoxin belongs to the group of antibodies. However, it does not act against parasites but protects from toxic injury.

Zusammenfassung. Swiss Mäuse, die unbehandelt eine Infektion mit *Pl. berghei* niemals überleben, wurden mit Serum von frisch infizierten Tieren (12. Infektionstag) immunisiert und anschliessend infiziert. Obgleich sich danach in allen Fällen eine schwere Parasitämie entwickelte, heilten 44% derjenigen Tiere nach dem 35. Infektionstag spontan aus, die mit 3 mg Serumprotein/Maus immunisiert waren. Wegen der offensichtlich eingetretenen Immunoblockade überlebten dagegen nach Immunisation mit höheren Proteinmengen (mehr als 30 mg per Maus) keine Tiere.

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