Technical Papers

Preliminary Observations on Intraspecific Variation of the Levels of Total Protein in the Sera of Some Decapod Crustacea[1]

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The total protein found in the sera of decapod Crustacea may vary from 0.5 g % in one species to 8 g % in another (*1–3*). Little information is available on the variation which may normally occur within a single species. Values among individuals of the same species that differ by as much as 3 g % have been reported (*3–5*). Since hemocyanins constitute virtually all the protein in crustacean sera (*6–8*), a recent paper (*9*) listing a broad range of values for the content of copper in the blood of the Australian marine crayfish, *Panulirus longipes* Milne-Edwards, might indicate that widely variable amounts of total protein could likewise be expected to occur.

TABLE 1

NORMAL RANGE OF TOTAL PROTEIN IN THE SERA OF DECAPOD CRUSTACEA

Species	Common name	No. of individuals	Range g/100 ml	Mean g/100 ml
Crustacea				
Callinectes sapidus Rathbun	Blue crab	31	1.83–12.00	4.39
Cancer magister Dana	Edible crab	26	1.16–13.75	4.45
Cancer irroratus Say	Rock crab	10	1.75–11.45	5.39
Libinia emarginata Leach	Spider crab	12	0.73– 7.25	4.14
Homarus americanus Milne-Edwards	Lobster	9	2.20–10.20	4.28
Arachnida				
Limulus polyphemus Linnaeus	King crab	28	0.77–13.45	5.92

Table 1 presents data on the total protein in the sera of several species of decapod Crustacea and one species of Arachnida. The range for each species is remarkable. *Cancer magister,* for example, has values which extend from 1.16 to 13.75 g %. This is a considerably wider range than has been previously reported for a single species; it also exceeds the cited ranges of values among different species. From the information in the table it appears that broad ranges are normal for species of decapod Crustacea and the marine arachnid *Limulus* (=*Xiphosura*) *polyphemus.* In general, the localities from which each species was collected were quite restricted and the number of individuals listed can properly be regarded as part of a single population for that species. *Limulus* is an exception in that these individuals were assembled from three widely separated localities (Massachusetts, New Jersey, and North Carolina). The small numbers of individuals listed for *Cancer irroratus, Libinia,* and *Homarus* were necessary in order to be reasonably sure that a single population was represented for each of these species. The ranges for these three species increased when the values (not included in the table) for the total protein from individuals collected at different times and other localities were added to the numbers representing the species. The sizes of the individuals within each species were variable, but no immature or small organisms were included in the comparisons. It is my conviction that the wide range of values presented for each species in Table 1 may normally be expected to occur in a natural population, at any given time.

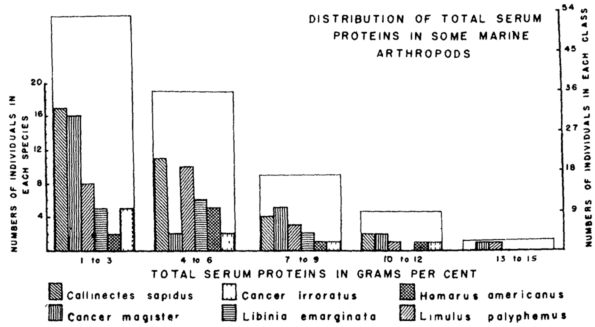

FIG. 1.

The arrangement of the values for the total serum proteins for each species is not a normal frequency distribution. An evaluation of the collective data reveals a continuous distribution over the entire range. By arbitrarily establishing class values of 2 ± 0.5 g % of protein, and by classifying all the individuals accordingly, the class of lowest values, 1–3 ± 0.5 g %, includes the most individuals and the class of highest values, 13–15 ± 0.5 g % has the least (Fig. 1).

The amount of protein in the sera of the brachyurans *Cancer magister* and *Callinectes sapidus* appears to be crudely correlated with the stages of the molting process. Papershell crabs generally had the lower values; thin hardshell crabs had the middle values; thick hardshell and peelers had the highest values. The level of the total protein in the sera of softshell crabs was more variable than for the other

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kinds of crabs. Observations similar to these were not made for the other species. More precise studies are indicated.

Much physiological data pertaining to the concentrations of inorganic ions in the blood and body fluids of Crustacea have been established from pooled samples from two or more individuals. If there is a correlation between the ionic composition and protein content of the blood (*2*), and if the latter varies as much, under uniform conditions of environment, as is indicated in Table 1, then errors may result from the practice of pooling the bloods before making determinations. It is entirely possible, also, that no relationship exists between the proteins and ionic concentrations of the blood. Further studies on this subject are needed.

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Occlusion of Copper and Zinc by Some Soil Materials of Lower Mississippi River Area[1]

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This preliminary note reporting a selective occlusion of small amounts of copper and zinc by some Mississippi River materials and by some soils derived from them is a part of a detailed report now in preparation. Observations on the occlusion of copper and zinc are parts of a general study of geochemistry of archaeological sites. The study itself was undertaken as a search for the means, the methodology, whereby the knowledge of weathering phenomena could be brought to bear on archaeological-anthropological problems, specifically, on the physical-chemical history of archaeological terrains.

Field indications and experimental evidence suggest existence of mechanisms in soil materials, soils, and parts of some soil profiles that are capable of occluding rather than exchanging very small amounts of copper and zinc, singly or in the presence of each other, under certain conditions. Such mechanisms exist in some but not in all of the materials examined. Their presence or absence may be correlated with origin and extent of weathering of the materials or horizons. The number of comparisons made so far is only 75 and, obviously, far more work is needed to ascertain the correlations and to identify the occluding mechanisms. The results obtained to date are so consistent, however, and the test employed is so simple and clearcut, that a preliminary note here presented appears to be permissible and, indeed, desirable.

A soil material shaken with a solution containing as much as 20 ppm Cu or Zn, singly or in the presence of each other, at the terminal pH from 5 to 8, responds generally in one of the following three ways: (*a*) both Cu and Zn are withdrawn from the aqueous phase quantitatively, (*b*) Cu is withdrawn but Zn is not, or (*c*) neither Cu nor Zn is withdrawn.

Reactions (*a*) and (*b*) take place at ordinary temperatures, seem to be instantaneous, and are reversible on the acid side of pH 2. They are not influenced by Ca^{++}, Mg^{++}, Na^{+}, Fe^{+++}, Cl^{-}, SO_4^{--}, HCO_3^{-}, CO_3^{--}, or NO_3^{-}, but are inhibited by citrate and, to a lesser extent, by tartrate and acetate. They are not affected by enriched bacterial or yeast growth on added sucrose or by the enrichment of denitrifying microorganisms. The occluding mechanisms are not impaired by prolonged heating of the soils in question at 300–400° and appear to be associated with the mineral rather than with the organic fraction of soils. The organic chelators or fixers of Cu and Zn were encountered only in some humous topsoil horizons but their study is outside the scope of this note.

The occlusion of Cu and Zn, in the amounts studied, is independent of their calcium carbonate content, or of the proportions of acid-soluble iron and possibly the entire iron group.[2]

Cu is occluded on the alkaline side of pH 4, and Zn on the alkaline side of pH 5.5 or so. The occlusion does not take place on the acid side of these ranges. On the alkaline side of about pH 8, the occlusion is obscured by other phenomena. Occluded Cu and Zn can be recovered quantitatively at pH 2, as a rule, and in still more acid solutions.

Soil materials that do not occlude Cu or Zn appear to be more kaolinized, on the whole, than the occluders of both Cu and Zn. However, a detailed study of the occluding factors still remains to be carried out, and it is not clear yet whether the factors or the surfaces in question are associated with certain series or species of the clay minerals. They may prove to be associated with simpler substances of colloidal dimensions, judging by the responses of some sands. The author regrets the unavailability of laboratory facilities for further work in this connection.

The only seemingly positive correlation between the occlusion response and the kind of occluding material

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[2] Freshly precipitated $Fe(OH)_3$ occludes both Cu and Zn on the alkaline side of pH 4. Amounts of occluded or coprecipitated Cu and Zn increase at pH 5, 6, 7, and 8, under comparable conditions. Zn is occluded by $Fe(OH)_3$ more readily than Cu. $CaCO_3$ added to lime-free nonoccluding materials seems to have no effect on the occlusion.