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SHORT NOTE:

International Study on *Artemia**. XXVI. Food Value of Nauplii from Reference *Artemia* Cysts and Four Geographical Collections of *Artemia* for Mud Crab Larvae**

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ABSTRACT: Nauplii from 4 commercially available geographical collections of *Artemia* and nauplii hatched from the Reference *Artemia* Cysts were compared for their effects on survival and growth of *Rhithropanopeus harrisii* larvae. In addition, nauplii from these sources were analyzed for their fatty acid and chlorinated hydrocarbon contents. Despite differences in the amounts of a few important polyunsaturated fatty acids (18:3ω3, 20:5ω3), as well as in the chlorinated hydrocarbon content, there was little variation in the survival and development rates of *R. harrisii* fed these *Artemia* sources as food. However, growth of *R. harrisii* from hatching to megalopa was significantly higher on the strain from France, intermediate in the Reference, Brazil and Chinese strains, and poorest on the Chaplin Lake (Canada) strain. The Reference strain is shown to be one of the better sources of *Artemia* nauplii with regard to their use in crab culture and therefore represent a good standard for future research studies.

The brine shrimp *Artemia* is extensively used as food source in the culture of larval fish and crustaceans. Although relatively expensive, *Artemia* is convenient to use and supports better larval development and survival than other live or artificial diets tested (Sulkin and Norman, 1976; Manzi and Maddox, 1980). There are, however, differences in *Artemia* composition that may alter the nutritional effectiveness of some commercially available sources of *Artemia* (Olney et al., 1980; Schauer et al., 1980).

The research reported here is a continuation of the effort initiated by the International Study on *Artemia* (Sorgeloos, 1980a) to characterize the biochemical composition and nutritional performance of commercially available sources of *Artemia*. Collections of *Artemia* tested were obtained from the following geographic areas: (1) Lavalduc, France, harvested 1979; (2) Tientsin, People's Republic of China, harvested 1979; (3) Chaplin Lake, Canada, harvested 1979; (4) Macau, Brazil, harvested 1978; (5) Reference *Artemia* Cysts (RAC), provided by the *Artemia* Reference Center, Ghent, Belgium. The RAC have been proposed as intercalibration material in studies using *Artemia* nauplii as food source (Simpson et al., 1980; Sorgeloos, 1980b).

Methods used for the detection of chlorinated hydrocarbons, as well as results of lipid analyses have been reported elsewhere (Olney et al., 1980; Schauer et al., 1980). For both of these analyses samples were run in triplicate.

Newly-hatched zoeae of the mud crab *Rhithropanopeus harrisii* were used as nutritional bioassay material. Methods for laboratory maintenance of gravid adults, procurement of newly-hatched zoeae and the exerpimental design used in this study have been described in detail by Johns et al. (1980).

The present study provides further information on variability in the biochemical composition and food value between different geographical sources of *Artemia*. Differences were found in fatty acid composition, total lipid content and chlorinated hydrocarbon contamination levels. The most noteworthy differences between the 5 *Artemia* sources were the higher level of 18:3ω3 in the Canadian and French strains and the high level of 20:5ω3 in the Chinese strain (Table 1). All strains contained substantial levels of 20:5ω3. (> 8 %). The total lipid levels of RAC, Brazilian and Chinese

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Table 1. *Artemia* spp. Weight percent fatty acid composition of various geographical collections of newly-hatched nauplii. nd: not detected

FAME	RAC	Brazil[1]	Canada	China	France
14:0	1.79	1.57	0.83	1.80	1.73
14:1	2.92	0.81	1.67	2.24	3.03
16:0	12.70	15.42	9.99	11.40	11.90
16:1ω7	16.78	10.79	9.03	19.06	11.34
16:3ω4/17:1ω8	4.33	3.88	1.47	2.54	2.20
18:0	4.07	2.79	5.12	3.99	4.21
18:1ω9	30.37	35.89	28.24	26.81	24.73
18:2ω6	9.62	9.59	7.95	4.68	6.14
18:3ω3	2.55	4.87	19.87	7.38	20.90
18:4ω3	nd	0.96	1.60	1.26	2.04
20:2ω6/20:3ω6	0.20	2.82	0.44	0.15	1.13
20:3ω3/20:4ω6	5.82	nd	4.21	3.34	2.45
20:5ω3	8.45	8.98	9.52	15.35	8.01
TOTAL %	99.60	98.37	99.94	100.00	99.81
Total Lipid mg g^{-1} dry wt.	209.4 ± 24.0	202.0 ± 8.0	142.9 ± 34.0	201.7 ± 0.3	152.1 ± 29.0

[1] Data from Schauer et al. (1980); 0.67 % 15:0 and 0.52 % 20:1 9 were also present

Table 2. *Artemia* spp. Chlorinated hydrocarbon content of various geographical collections of newly-hatched nauplii. Results expressed as ng g^{-1} wet weight (ppb). nd: not detected

	RAC	Brazil	Canada	France	China
HCB	0.3	0.1	0.3	1.8	97.0
PCB 1016	1.0	5.3	6.2	8.6	6.3
PCB 1254/1260	0.2	1.6	5.6	32.0	43.0
Σ PCB's	1.2	6.9	12.0	41.0	49.0
ppDDE	1.4	1.2	3.0	14.0	85.0
ppDDD	0.4	0.4	0.4	3.8	22.0
opDDT	nd	0.4	nd	nd	0.9
ppDDT	0.3	1.9	nd	7.1	64.0
Σ DDT's	2.1	4.3	3.4	25.0	172.0
α-BHC	0.2	1.1	1.6	0.3	23.0
γ-BHC	nd	0.8	nd	2.2	16.0
t-Chlordane	0.1	nd	0.1	0.3	0.4
c-Chlordane	nd	0.1	nd	0.4	0.2

[1] Data from Olney et al. (1980)

Table 3. *Rhithropanopeus harrisii*. Summary of culture data for larvae fed various geographical collections of newly-hatched *Artemia* spp. Data presented as mean ± one standard deviation. Means having the same grouping letter are not significantly different ($P > 0.05$). (n) sample size

Artemia source	Survival to megalopa (%)	(n)	Grouping	Development time to megalopa (d)	(n)	Grouping	Megalopa dry weight (μg)	(n)	Grouping
French	89 ± 13	60	A	11.1 ± 0.2	53	A	181 ± 10	53	A
Reference	89 ± 10	60	A	10.9 ± 0.2	50	A	166 ± 13	50	B
Brazilian	85 ± 10	60	A	10.7 ± 0.3	53	A	161 ± 13	53	B
Chinese	84 ± 17	60	A	10.9 ± 0.3	51	A	168 ± 27	51	B
Canadian	72 ± 25	60	A	11.6 ± 0.6	43	A	144 ± 18	43	C

nauplii were higher (> 200 mg g^{-1}, dry wt sample) than the level found in the French and Canadian populations (< 155 mg g^{-1}, dry wt sample).

All values for chlorinated hydrocarbons were below 100 ppb, except for the total DDT's in the Chinese sample (172 ppb; Table 2). Lowest levels of CHC were found in RAC and Brazilian collections; French and Chinese *Artemia* were approximately 4 to 6 times more contaminated. Despite such chemical variation no significant differences were found in the ability of the various *Artemia* sources to support survival and developmental rate of *R. harrisii* larvae (Table 3).

Growth rates, however, were significantly higher in crab larvae fed nauplii from the French source; the poorest growth was found in crab larvae fed Canadian brine shrimp. Growth was fastest on the French strain which contained one of the lowest lipid levels, therefore it appears that lipid levels were adequate in all *Artemia* strains. In addition, growth did not appear to be affected by the moderately high levels of contaminants found in the French strain. Although no significant differences were found in survival and developmental rates, the lowest mean values for survival and growth and the slowest development rate occurred with mud crab larvae fed Canadian brine shrimp nauplii. These trends suggest that the Canadian source of *Artemia* may be less effective in culturing larvae of *R. harrisii*.

The value of studies such as this would be of little interest if a single, reliable source of *Artemia* was commercially available. This has not been the case (Sorgeloos, 1980a). For example, *Artemia* from Macau, Brazil, which had been identified as one of the better food sources for a large variety of marine fish and crustacean larvae (Beck et al., 1980; Johns et al., 1980, 1981; Klein-MacPhee et al., 1980) are presently not commercially available (P. Sorgeloos, pers. comm.). The ISA series of studies, however, have highlighted major differences in the nutritional effectiveness of other commercially available sources of this indispensible source of food for marine and freshwater organisms (Sorgeloos et al., 1980a).

The use of *Artemia* of inferior quality could be an unexpected and confounding source of variation in experimental results. Although there is no ready solution to this problem, the use of RAC in experiments can give researchers a relative indication of the nutritional effectiveness of other *Artemia* sources they are using in the laboratory. Nauplii of the RAC have been tested for their nutritional performance in the culture of larval fish (Klein-MacPhee et al., in press) and crabs and have been found to be one of the better *Artemia* sources thus far tested by the ISA. The use of RAC as an intercalibration food source in experiments could reduce the number of incorrect inferences caused by the poor nutrititive value of an uncharacterized laboratory diet.

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