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Robin M. Overstreet

Gulf Coast Research Laboratory, robin.overstreet@usm.edu

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PRESIDENTIAL ADDRESS*

FLAVOR BUDS AND OTHER DELIGHTS

Robin M. Overstreet

Department of Coastal Sciences, Gulf Coast Research Laboratory, The University of Southern Mississippi, P.O. Box 7000, Ocean Springs, Mississippi 39566. e-mail: robin.overstreet@usm.edu

Like the addresses of Lillian Mayberry (1996) on intentional infections for scientific purposes and of Larry Roberts on “science literacy” and pseudoscience in parasitology (1999), I picked 1 that may interest a broad spectrum of scientists. I hope the presentation will allow you all to appreciate another view of parasites and parasitic infections, a view that might be approached differently by a squeamish nonparasitologist.

Of the parasites that infect humans and other animals, a large percentage is acquired orally through the diet or by accident. Most of these parasites are embedded in the tissues of the dietary items and are not seen by the consumer. This address focuses on intentionally eaten parasites and not on the infected tissue or the parasites acquired incidentally. Some of the examples involve parasites that are not eaten or acquired incidentally, but they allow the reader to understand aspects of infections or perceptions of the people involved with the activities. Humans recognize that some of these parasites, whether eaten or not, may infect them. However, most of these parasites or the products containing these parasites are either cooked or otherwise treated so that either they are no longer infective or the decision to eat them results from a cost-benefit analysis. In other words, the benefits of one eating the parasite is weighed against the potential harm that he or she could experience. One might ask why someone would intentionally eat a parasite. There are several reasons, as you will see! Other parasites are not recognized as parasites by the consumer; so, in those cases, the risk is never realized.

ACTIVITIES AND ORGANISMS

Weight loss

Of those parasites that infect humans, some are intentionally eaten so that the consumer can lose weight, as indicated on some old posters (Fig. 1). This approach to losing weight is not popular today, and, at least in my case (Mayberry, 1996), the parasite does not reduce one's weight. In fact, one can gain weight soon after eliminating the worms. In some cases, however, the consumer does not know a worm has been eaten. The cysticerci of the pork tapeworm, *Taenia solium*, have been fed by unprincipled medical advisors to unwitting Hollywood actresses in the 1930s as “slimming pills,” producing adults in the intestine (Russell-Hunter, 1979).

Treating diseases with parasites

Considerable early history has included records of both Chinese and Western (=European) medicine using parasites as a means to treat disease. Hoepli (1959) extensively reviewed the subject, drawing on published western literature from the 1500s

(e.g., Aldrovandi and Pliny) as well as earlier (Dioscorides, about AD 50) up to the present time, and comparative information from the Chinese literature, drawing on the extensive multivolume pharmacopoeia *Pen Ts'ao Kang Mu* (*The Great Herbal*) compiled from antiquity by Li Shih-Chen in 1596 and other works up to the present time. Hoepli discovered that most of the same parasitic species were used by all the parties; however, the infections and diseases treated by those parties differed. For example, western medicine considered the fluid, pulverized dry tissue, and ashes of the nematode *Ascaris lumbricoides* (and in a few cases powdered *Taenia* sp.) as a vermifuge, but the practice, questioned by Hoepli (1959), may have some validity (see cited studies by Weinstock and colleagues discussed below). As a sidebar, other authors considered that ascaris powder would generate new worms, and others thought the worms were beneficial because either they were transformed from harmful substances or the worms ate “nutrient juices” and benefited the intestine. Chinese used the nematode fluid (fresh or from putrefied worms), ashes, and powder for ophthalmic diseases and anal fistulas, and, when mixed with other powders and grease, they used it as an aphrodisiac. Because of the cooling effect of the fluid and irritating nature of the powder, the treatments probably have some merit, albeit clearly not modern treatments of choice.

Both Western and Chinese cultures also used arthropods. Western medicine considered swallowing live human lice (*Pediculus humanus* and *Pediculus capitis*, considered as 2 subspecies of *P. humanus* for the body and head lice) or the hog louse (*Haematopinus suis*) as a method to cure jaundice and in some cases colic, ulcers, obstructions, and other ailments; the Chinese pulverized the human louse into a paste as a salve for headaches and external ulcers. They also made a paste for external sores with the bed bug, *Cimex lectularius*, which they also used for other treatments, sometimes after washing off the harsh odor with water. In Western medicine, the bed bug has been used for at least 2,000 yr, and its odor allegedly stops nose bleeding. According to Dioscorides (about AD 50), 7 bed bugs taken with beans before a fever attack was valuable in treatment of malaria, and when taken without the beans, the bed bug was used to treat viper bites. In contrast, to cure chronic malaria, the Chinese pulled the wings and legs off a live dog hippoboscid (perhaps *Hippobosca capensis*), rolled the fly in dough to produce a pill that they coated with yellow oxide of lead, and swallowed it with rice gruel. The “pill” was directed to be taken early in the day of the next expected fever attack.

Hoepli (1959) presented many more cases, with more details and corresponding references. For the most part, he considered that the treatments probably had little merit, but I think some may deserve investigation. On the other hand, the practices usually did not seem to harm the patients. Practices in third world countries seemed to have especially poor success.

* Presidential address, 78th Annual Meeting, American Society of Parasitologists, 2 August 2003, Halifax, Nova Scotia, Canada.

FIGURES 1, 4–6, 14, 22–24, 26–29. **1.** An “old” poster advertising the use of tapeworms for weight loss. Provided by Bruce Christensen. **4.** Chocolate-dipped scorpion for commercial sale in the United States. From Menzel and D’Aluisio (1998). **5.** Native New Guinean grooming another aboard a boat. From Archbold and Rand (1940). **6.** Ecuadorean native biting flea groomed from another, unknowingly risking tonsillar plague. Provided by Bruce Christensen. **14.** A young Nunamiut woman eating *Oedemagena tarandi* from the hide of a reindeer in the Brooks Range of northern Alaska. From Ingstad (1954). **22.** Mealworms being fried by Montréal Insectarium for its “insect tasting.” Provided by David Marcogliese. **23.** Biologists indulging in a plateful of deep-fried tarantulas in Cambodia. Provided by David Cone. **24.** Moderate-sized specimen of the giant liver fluke, *Fascioloides magna*, from white-tailed deer. **26–28.** Trypanorhynch *Poecilancistrum caryophyllum* from the flesh of the spotted seatrout, *Cynoscion nebulosus*. **26.** The average 2 plerocercoids found in a fish but assumed by consumers to be more because the

Some parasitic treatments may have harmful effects, as exemplified by Bantu “medicinal” practices used by native herbalists in southern Africa (Heinz and MacNab, 1965). To expel adult tapeworms (*Taenia solium* and *Taenia saginata*) from the intestine, many herbalists and users of home remedies used dried proglottids of *T. solium*. Segments voided by humans would be dried by the heat of the sun or a gentle fire. This material would be ground and included in potions, called “muti,” to be fed to the infected people or, in some cases, the ground-up worms would be applied to cuts in the skin. These “treatments” when applied externally to cuts resulted in a relatively high prevalence of cysticercosis throughout the body or locally.

Treating immunological diseases

A few studies have used parasites to control nonparasitic diseases. The reason some people do not exhibit some specific parasitic or other diseases may be because they are infected by certain other helminth parasites. Immunoparasitologist Joel Weinstock (University of Iowa) and colleagues first fed mice eggs of *Schistosoma mansoni* so that the antigens in the eggs could induce a chronic focal granulomatous inflammatory response, which then set off a series of immunoregulatory activity in the intestinal mucosal surface. Animal studies suggest that the worm presence suppresses the Th1 immune response, which can attack normal tissue, and enhances the Th2 response and forms a more healthy intestinal environment, perhaps capable of controlling unrelated parasitic, bacterial, and viral diseases. A few experimental human cases with the whipworm indicate that the somatostatin circuit, specific fucoprotein induction, and other activities can produce at least temporary remission of inflammatory bowel diseases, such as ulcerative colitis or regional enteritis (Crohn’s disease). Deworming can produce a re-emergence of the immunological disease (e.g., Weinstock and Elliott, 1998; Elliott et al., 2000, 2002; Weinstock et al., 2002). Imagine, physicians may start using some helminths to treat immunological bowel diseases! Some early western medical treatments considered ineffective by Hoeppli (1959) may have had merit.

Gain social status

In the United States, a few people knowingly eat a human parasite to achieve some sort of social status, including “shock value,” the ability to shock or alarm others. Often children eat free-living earthworms for these purposes, especially for those in the general public that do not differentiate helminths from free-living “worms”! On the other hand, fishermen who get bored after not catching fish eat their bait, tavern clients claiming attention, or college students undergoing their “rite of passage” swallow live killifish, even those swollen with juveniles of *Eustrongylides ignotus* (Figs. 2, 3) (e.g., Deardorff and Overstreet, 1990). Even though a means to gain social status, to elicit “shock value,” or to avoid ridicule or punishment, these

cases are not comparable with most others in this address because the partaker does not see the worm, does not realize the swollen portion of the fish results from a nematode, or does not understand the high risk of contracting peritonitis.

“Playing around with danger” appears to be an important aspect of eating what many groups of people, including most Americans, think of as mighty strange or stupid. But not all such food-related activities involve parasites. In China, what Menzel and D’Aluisio (1998) call the “stinger zinger,” the scorpion *Mesobuthus martensii* serves this purpose. When eating this scorpion raw, the stinger and venom sac should be removed because the venom can be absorbed through the mucosal membranes. If the structures are not removed or the toxin inactivated, the consumer takes considerable risk. Heat breaks down this toxin that rarely kills adult consumers, but young children are especially vulnerable. In the United States, where most of the danger but not the perceived “danger factor” or “attention-getting mechanism” has been eliminated, specialties including scorpions are being safely produced on a commercial basis. These include chocolate-dipped specimens (Fig. 4) and candy-coated ones called “InsectN sides” (Menzel and D’Aluisio, 1998).

Eating parasites for other than a dietary reason apparently reached a new extreme on KarKar Island just north of Madang along northern Papua New Guinea, where contestants intentionally ate parasites. On “Parasite Day,” they took a pill treatment, and the one that expelled the heaviest load of worms was the winner. The description of this recent event was on the Internet, but when I tried to obtain the details, the site was apparently no longer in operation.

Scientific rationale

Mayberry’s (1996) presidential address centered around parasitologists infecting themselves and their graduate students. The rationale for these infections or attempts to infect themselves or others included (1) the elucidation of a life cycle, (2) importation of a parasite across borders, (3) availability of teaching material, (4) avoidance of difficulty of involving use of human subjects, (5) a publication for merit evaluation, (6) possession of one’s own parasite, and (7) a vehicle for homicide. These cases will not be repeated here.

Evolutionary and social aspects

In *The Naked Ape*, Morris (1967) discussed “social grooming” under the heading of “comfort.” Just as birds need to bathe, preen oil, and scratch to adequately avoid predators, maintain proper body temperature, and rid parasites, mammals need to groom, lick, nibble, scratch, and rub to maintain their warmth and keep their parasites at a manageable level. An evolutionary progression occurs in social grooming among animal groups. It reaches its peak in higher primates, which have 2 hands and talented fingers. Monkeys and apes all have an abundance of hair, but each has a hard time grooming its own back

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entangled worms are cut a few times. From Overstreet (1983). 27. Close-up of 5 plerocercoids showing bulbous portion enclosing scolex. From Overstreet (1977). 28. Released scolex. From Overstreet (1978). 29. Plerocercoid of *Ligula intestinalis* from the body cavity of a Michigan cyprinid, which measured much shorter than the worm.

FIGURES 2-3, 7-13, 15-20. 2-3. The Gulf killfish, *Fundulus grandis*, infected with juveniles of *Eustrongylides ignotus*. 2. Seen through the flank. 3. Body cavity of same fish cut open, showing worms. 7. Head louse egg (nit) cemented to human hair, the source of the terms "nit-picking" and "getting down to the nitty-gritty." 8. "Cotton shrimp" caused by the microsporidian *Perezia nelsoni* in the abdomen of the brown shrimp, *Farfantepenaeus aztecus*, in Mississippi. Shrimp on right is uninfected. The microsporidian is 1 of several that infect the skeletal muscle of penaeid shrimp, causing the disease and discouraging consumption of the infected product. 9. The microsporidian *Agmasoma penaei* infecting nonskeletal muscle of the white shrimp, *Litopenaeus setiferus*, and confusing many consumers, who eat and enjoy the product, thinking they are

and the rear of its own head and arms. By using a more evolved mutual aid system than birds and other mammals, a higher primate groomer signals a potential groomee with a facial expression, usually lip smacking, often sticking out the tongue between smacks. The resulting nonaggressive cooperative grooming activity creates a bond of friendship between members of a troop or colony. Consequently, picking parasites off another provides a means to show appeasement (reduce the aggression of a dominant animal by the grooming performed by the subordinate counterpart) and reassurance (a dominant groomer calming the fears of a weaker member). In humans, the lip smacking has been replaced by smiling, and because there is less hair to groom, the reduced amount of time necessary for grooming appears to be replaced with verbalized vocalization. This vocalization started with “information talking,” and led to “mood talking” and “exploratory talking” or “play talking.” Finally, humans developed “grooming talking” or meaningless polite social chatter. Yes, if this analysis by Morris (1967) is correct, humans learned to talk because parasites could be eliminated in less time than was required for social bonding in lower primates. In any event, grooming has continued among humans, and additional researchers have continued to produce scientific assessments of the evolution of grooming behavior.

In addition to similarities in grooming by humans and other primates, evidence exists for humans passing the custom down from generation to generation. According to Hoepli (1959), Herodotus (500–424 BC) mentioned the Budini nomads on the Middle Volga of Europe as louse eaters. Then 2,200 yr later, Nazaroff found the same habit among the Kirghiz and Kazaks, descendants of the Budini.

Hoepli (1959) provided an extensive history of people around the world eating lice, most often as a delicacy and with evident pleasure. These people in the western hemisphere included the Cheyenne, Snake, and Chipewyan Indians as well as other Arctic natives from North America, Indians from Cuena, Mexico, and Indians from the West Indies, Panama, Amazon, Peru, Ecuador, and Brazil. Lice eating also has been documented from the forest-dwelling Mois in Cambodia, Chinese from Cochin, natives from Southeast Asian island nations (Fig. 5), and natives from various Oceania islands in the South Pacific. Hoepli (1959) considered the practice not very esthetic but not very harmful either. He considered the activity dangerous only for those people who eat lice in regions where typhus or relapsing fever (and trench fever) is endemic. On the other hand, some people showed enthusiasm for additional reasons.

The Hottentots of Africa say of the lice, “They suck our blood and we devour them in revenge.”

Eating arthropods while grooming or preening still seems to be practiced by people throughout the world from both developed and underdeveloped countries. For example, Colin Dobson (pers. comm.) related to me stories of how 8- to 10-yr-old British school children would comb the pests onto a table, watch them scurry about, pick them up, and then bite and eat them. Consequently, bonding among family and group members seems to be aided by “nit-picking” and by removing arthropods from each other’s hair or body, whether as a special dietary treat, a means to gain attention, or “revenge.”

Associated risks from eating arthropods

All ticks, lice, and fleas may not be considered as parasites in the sense of some definitions, but regardless of one’s definition, some species transmit human parasites and diseases as “vectors” or as intermediate hosts. As Jonathan Swift wrote in 1733 in conjunction with the invention of the microscope, “Big fleas have little fleas upon their backs to bite ’em; and little fleas have lesser fleas, and so ad infinitum.” Examples of diseases transmitted by members of the 3 arthropod groups include Rocky Mountain spotted fever, typhus (rickettsias), epidemic (louse borne) and endemic (from soft ticks) relapsing fever, Lyme disease (spirochetes), Q fever, tularemia, and trench fever, plague (gram-negative bacilli); encephalitis, and Colorado tick fever, and hemorrhagic fever (viruses); babesiosis (protozoans); and worms (tapeworms and nematodes). These can be acquired by eating the arthropod or by crushing it or its feces against the body, depending on the agent (e.g., Beaver et al., 1984). Figure 6 shows Ecuadorean natives picking fleas and then biting them to kill them, just as lice are bit. In this case, the behavior can result in contact of the groomer’s lymphoid tissues with associated flea material, including the bacterium *Yersinia pestis* that multiplies in the blood from the flea’s gut. The consumers thereby unknowingly risk infection with tonsillar plague.

As another sidebar, according to Hoepli (1959), Aristotle (384–322 BC) was aware of lice and their ova (nits) glued to the hair shafts (Fig. 7) on a variety of animals. However, Aristotle thought the eggs did not develop and did not give birth to anything. He recognized that lice, fleas, and some bugs fed on fluid rather than flesh. He considered each of them to develop a little differently, with all the lice species developing from the animals that they infested.

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eating a shrimp with ripe ovarian tissue. **10.** Female Pacific white shrimp with dorsal portion removed, demonstrating ovary extending along medial portion of tail (bottom third of figure). Provided by John Ogle. **11.** Female Pacific white shrimp with 2 hard spermatophores (cream colored) attached. One occurs in the external genital organ and the other had been misplaced by a male. The spermatophore has been misinterpreted as a parasite, discouraging people to consume the product. Provided by John Ogle. **12.** Adult female of the grooved mussel crab, *Fabia subquadrata*, with carapace width measuring 15 mm, in the mussel *Mytilus californianus*. From Garth and Abbott (1981). **13.** The mottled pea crab, *Opisthopus transversus*, in the mantle cavity of the gaper, 1 of its many different invertebrate hosts. The host apparently influences crab color indirectly by limiting the amount of carotenoid pigments available. From Garth and Abbott (1981). **15.** Close-up of caribou hide showing warbles of *Oedemagena tarandi*. Provided by Nikolas Konstantinou. **16.** Inuit from northern Baffin Island, Canada, holding warbles of *O. tarandi* from the hide of a caribou before eating them. Provided by Nikolas Konstantinou. **17–19.** Witchetty worm (caterpillar of a giant moth in the genus *Cossus*) from Australia. **17.** Worm being eaten raw by Aboriginal inhabitant from Papunya. From Isaacs (1999). **18.** Live worms in hands of Aboriginal gatherer. From Menzel and D’Aluisio (1998). **19.** Worms lightly cooked in ashes and ready to eat. From Isaacs (1999). **20.** Native child from Irian Jaya, Indonesia, eating roasted sago-palm worms on a skewer. These grubs were obtained from the fermenting pulp of a rotting sago palm. From Menzel and D’Aluisio (1998).

Parasites that typically do not harm the consumer or those that are eaten mostly for pleasure

As indicated above, people intentionally consume parasites for a number of reasons. The primary reason, however, probably involves nutrition or pleasure. Most of the remainder of this presentation addresses parasites (or other symbionts) or products infected with parasites that are intentionally eaten with little perceived risk of producing human infections. The intentional act of eating them, however, often esthetically displeases most of the nonparticipating bystanders but seldom the consumer. The activity can be performed to enjoy a "flavor bud," usually a larval or juvenile stage of some helminth embedded in the flesh of a fish or other product being used for an otherwise routine dish, but participation in the activity sometimes is dictated by local, social, or ethnic practices. The consumer may know the morsel is a parasite or the product is infected, or he or she may see the parasite but consider it as a normal part of the host being consumed rather than a parasite. Moreover, similar practices and customs that involve eating parasites occur nearly worldwide. Some examples of these will be compared with similar ones involving nonparasitic insects and other invertebrates since eating some of these free-living organisms elicits the same pleasures, disgust, and emotions as eating parasites.

Protozoans: Few protozoans are intentionally eaten. One example involves the commercial white shrimp (*Litopenaeus setiferus*) from the Gulf of Mexico when infected with the microsporidian *Agmasoma penaei*. The infected shrimp is considered a premier seafood product, but the tissue infected with literally millions of spores about the size of a human red blood cell is confused as the shrimp gonads. Many coastal residents are knowledgeable about cotton shrimp and do not eat them, even though most probably do not realize that the chalky-white shrimp abdomens result from a parasitic infection (Fig. 8) and that several different microsporidian species can be responsible (Overstreet, 1973; Canning et al., 2002). Since *A. penaei* does not normally infect skeletal muscle like the other species, shrimp infected with it fall into a different category. The microsporidian reproduces in nonskeletal muscle (Fig. 9), producing extensive masses in the hemocoel and gonads, resulting in confusing an infection for ripe gonads. Since most noncommercial fishers for shrimp never see ripe shrimp (Fig. 10), the confusion is not unexpected. Most of these people capture shrimp in in-shore waters, but these penaeids mature and spawn near passes or offshore. On the other hand, the ripe shrimp can provide an especially tasty seafood product as well as a very expensive source of broodstock for some aquaculture facilities. Also, the spermatophore, a male structure used to incorporate and transmit the sperm to the female is occasionally seen on females by shrimpers from offshore, and this structure (Fig. 11) can be confused by them as a parasite, since even they rarely observe mating and the spermatophore can easily be dislodged from the female's genitalia (thelycum). Consumers typically reject a female shrimp with an attached spermatophore.

Crustaceans: The arthropod examples mentioned above infect mostly mammals, usually humans. Most people typically consider them "parasites," even though some are just temporary blood feeders. People throughout the world eat a variety of parasitic arthropods other than those human ones. Some ad-

ditional "arthropods in the wide sense" also constitute tasty morsels, if one wants to treat crustaceans as a separate phylum.

Some parasitic copepods and probably other blood-feeding crustaceans that infest fishes and marine mammals are eaten. Probably the best-known case involves the pennellid *Lernaeocera brachialis* attached in the buccal or branchial cavity of various codfishes and whiting, with its anterior body portion penetrating into the ventral aorta, bulbous arteriosus, or ventricle of the heart. In the Arctic, blood-filled individuals provide a gastronomic treat for Inuits. These people, however, obtain an even larger parasite snack by eating *Pennella balaenopterae*, a poorly understood species that can grow to monstrous proportions. Specimens up to 30 cm long routinely embed deeply into the blubber of baleen whales, with the posterior of their bodies trailing free from the host. The plump and juicy body extremity is plucked from the host and eaten raw, and the "sweet" contents of the blood-filled neck are sucked out. In more southerly waters, fishers seem to be missing out on these special treats since they do not appear to consume *Pennella instructa* and *Pennella filosa*, 2 related species that infest fishes such as the swordfish.

Aristotle (from Hoeppli, 1959) was also aware of pennellids and other copepods on marine fish, but he grouped the known genera as lice. Unaware of the actual life cycles, he thought they formed not from the fish, since he considered lice and fleas as eventually forming from putrefied flesh, but from the mud or slime. I do not know if they were consumed during that time.

Other edible parasitic crustaceans, exemplified by a series of pea crabs, follow as do insects, including the botflies. Pea crabs constitute a delicacy for many people, but they are not considered a parasite by some lay individuals because they infest an invertebrate. These are bite-sized pinnotherid crabs that have an association with a bivalve but can be found also by the diligent seafood lover, who carefully inspects tube-dwelling polychaetes, gastropods, holothurians, sea urchins, and tunicates. Some pinnotherids are highly host specific, and others occur in several different hosts, with individuals of some species even switching from one to another host, but usually occurring as an adult in 1 or few "definitive" hosts.

The common oyster inhabitant, *Zaops ostreum* (previously and still commonly called *Pinnotheres ostreum*), in the eastern oyster (*Crassostrea virginica*) along the eastern U.S. coastline probably serves as the best example. An understanding of its life cycle allows a consumer to appreciate better the food source. The pea crab invades the bivalve host as a first stage crab. Relatively soft juveniles, both smaller males and larger females, live in the water-conducting system, grow, and molt together in an oyster. When approaching maturity, the 1- to 5-mm-wide crabs molt and form a hard shell. They then leave that specific host individual, males and females mate, the male dies, the female reenters an oyster, it keeps other crab individuals away, and it grows. However, 10 or so of these hard crabs may remain in 1 oyster over the winter months before mating and migrating to other oysters. The larger, 4- to 15-mm adult female that reenters has only a thin membranous carapace (shell), so its soft body is unsuited to life outside the mollusc. As her egg mass develops, she appears first orange and then brown (Christensen and McDermott, 1958). While feeding on the oyster's food and mucous strings, the crab can erode the gills, enlarge the mantle cavity, have a harmful effect on the

host, occasionally kill it, and constitute a true parasite (Stauber, 1945). Since only 1 adult female occurs in an individual, it seldom kills its host. The young crab invades oyster spat and causes delimited tissue erosion, but survival of individuals is greater in older oysters, even though gills are shortened and all individuals exhibit some damage. The effect on the host seems more conspicuous in older oysters with a single large female. Haven (1958) found less oyster tissue per shell volume (a lower condition factor) in infested oysters in almost all samples and less mean oyster volume in June.

This delicacy from the oyster occurs abundantly in the high-salinity water where hosts are submerged longer along the Atlantic coast, with infestations ranging from 1 to 80% and averaging around 35% in Virginia during the mid 1940s (Sandoz and Hopkins, 1947). *Zaops ostreum* rarely infests hosts other than the eastern oyster. In the Gulf of Mexico, where the oyster pea crab species is relatively uncommon (Butler, 1954), my technician Ronnie Palmer and I saw the oyster pea crab in oysters from Mississippi over 3 decades ago but never recently. Because this may be a new locality record, I confirmed it with William Demoran (pers. comm.). He said he also saw that pea crab in Mississippi during the late 1960s only, when it infested nearly 100% of the oysters in the relatively deep, relatively high-salinity water on the outer reefs off Pass Christian, Mississippi. Infestations occur more commonly in the high-salinity water of Texas.

The oyster pea crab, as indicated above, is a soft shelled species as an adult and much easier and more pleasant to eat than others, such as the less commonly eaten *Tumidotheres maculatus* (usually referred to as *Pinnotheres maculatus* in the literature), which is much more crunchy and setose. The latter infests a wide range of bivalve hosts as a juvenile, including up to 80% of the mussels (Kruczynski, 1974), as well as in the tube of the polychaete *Chaetopterus variopedatus*. As an adult, it infests at least the bay scallop (*Argopectin irradians*) and pen shells (*Atrina serrata* and *Atrina seminuda*).

In any event, Rombauer and Becker (1963) in *Joy of Cooking* mentioned that the crispy, pinkish "boarders" in the shell of an oyster may be sautéed or deep fried as well as eaten raw. They suggested a portion as constituting several dozens of these fried morsels along with the same number of fried, crisp, whole whitebait, tasty juveniles of clupeoid fishes. *The Fannie Farmer Cookbook* provides additional recipes and information (Perkins, 1965). It states that oyster crabs are sold by the pound at specialty shops in a few large cities and that a pound serves 8 as the fish course at a formal dinner. In addition to sautéed, fried, and fried with whitebait, the fried crabs can be served with cucumber sandwiches made with brown bread. The specialty dish is "oyster crabs Newburg." To a cooked sauce with melted butter, flour, salt, cayenne, nutmeg, and heavy cream, one adds a mixture of broken mushroom caps, oyster crabs, and sherry that has stood for an hour. Just before serving, the cook heats and stirs in slightly beaten egg yolks and brandy.

Pea crabs occur along the coastlines around the world (e.g., Silas and Alagarwami, 1967) and may be eaten from many of those habitats. Most follow the life-cycle pattern found in the 2 pinnotherids above. For example, juveniles of the gaper pea crab, *Pinnixa littoralis*, and the mantle pea crab, *Pinnixa faba*, along the western mainland U.S. coastline occur in multiples in a variety of bivalves, and the adult female occurs in specific

bivalves. As a young boy, I was taught by Oregon locals to eat or crunch a few of these little crabs raw and set most aside in a bowl or bucket to later add to the stew or other special dish we were having. Most of my successful catch of both juveniles and adult females came from the fat gaper, or horse clam (*Tresus capax*), but I encountered a variety of different pinnotherids from a variety of bivalves. Also along the entire Pacific U.S. coastline, the grooved mussel crab (*Fabia subquadrata*) occurs in *Mya arenaria*, *Mytilus edulis*, and *Mytilus californianus* (Fig. 12) (and occasionally in clams, sea urchins, and tunicates). Rarely do mussels longer than 85 mm contain the pea crab, and recently mated female crabs usually seek mussels less than 15 mm long (e.g., Garth and Abbott, 1981). Also well known from mussels is the British pea crab *Pinnotheres pisum*, which infests hosts from deeper water, like the pinnotherids known from other mussels. An example of a species that infests a wide range of hosts, all living in protected habitats (cloaca of sea cucumbers, tubes of polychaetes, gills of chitons, and mantle cavities or pallial grooves of various clams and gastropods in California and Baja California) is the mottled pea crab, *Opisthopus transversus* (Fig. 13). The host apparently influences crab color indirectly by limiting the amount of carotenoid pigments available, making a limpet, bubble snail, and sea hare the best hosts from which to find those with bright-red mottling as garnish (Garth and Abbott, 1981).

Botflies and other insects: As in most diverse areas of the world, natives of the Arctic region have their own delicacies. One of those delicacies is the common botfly maggot, *Oedemagena tarandi*, from the hide of the 3 "subspecies" of the caribou (*Rangifer tarandus*), including that referred to as reindeer. Robert Rausch spent considerable time with the Nunamiut (nuna = land; miut = dwellers), the last of the nomadic Inupiat and the last of the native people who existed as nomadic hunters that followed the reindeer in the Brooks Range (Rausch, 1951). In May, the reindeer-warble, *O. tarandi*, reaches its greatest size prior to pupation, and at that time, the Nunamiut ate the warbles, which were exposed in large numbers lying just below the skin on the back when the caribou were skinned. The hunters would bring in the heavily infected hides, and everyone would remove these warbles from the small pocket of surrounding inflammatory tissue and immediately eat and enjoy them alive in their entirety (Fig. 14). According to Rausch, they tasted quite good, with the hemolymph providing a saline sensation and the remainder of the warble having a nutlike flavor. On a few occasions, he also ate them cooked, but they did not taste as good as the raw ones (R. Rausch, pers. comm.). The natives, whose language was oral only and took them about 4 decades to learn, had a name for the botfly and most other organisms. They called the botfly larva "Kumak" ("Kummak" if 2 and "Kumaich" if 3 or more, with the same names applied to the human head louse), and they called the adult fly "Igutchatchiaq" (derived from the bumblebee "Igutchaq"). According to Robert Rausch (pers. comm.), the youngsters, now living with their parents in a modern village at the divide of the Yukon and Arctic drainages, are not learning the language and probably do not eat the warbles.

According to Kennedy and Newman (1986), 2 species of botflies occur in the caribou in addition to *Oedemagena tarandi* (*Cephenemyia trompe* in the throat and gullet and *Cephenemyia phobifer* in the nasal passages and retropharyngeal pouches).

FIGURES 21, 25, 30–37. **21.** Caramel apple with mealworms being prepared by a U.S. commercial company. From Menzel and D’Aluisio (1998). **25.** Flesh-infecting trypanorhynch spaghetti worm, *Pseudogrillotia pleistacantha*, in the black drum, *Pogonias cromis*, unheralded as improving taste of cooked fillet. **30.** Adult anoplocephalid *Bertiella esculenta* from the intestine of a coppery ringtail possum, *Pseudocheirus cupreus*, being eaten by native of Papua New Guinea. From Flannery (1998). **31–33.** Children from Irian Jaya, Indonesia, using leaf packages to roast stinkbugs just like those used by other peoples throughout New Guinea to roast helminth parasites. From Menzel and D’Aluisio (1998). **31.** Boys holding leaf packages, each holding about 20 stinkbugs. **32.** Boys roasting bugs over fire and eating them. **33.** Close-up of 2 such tasty bugs in mouth. **34–36.** Marine shipworms, bivalve molluscs, that tunnel through most wood in the marine environment throughout much of the world and provide a good human food source, if properly prepared. From Isaacs (1999). **34.** Mangrove root in the Gulf of Carpenteria, Australia, containing numerous worms. **35.** Small ax used to harvest the worms from the mangroves. **36.** Arnhem girl in the Gulf of Carpenteria eating a shipworm raw after removing both ends and the internal organs. **37.** Fresh marine nereid polychaetes in container at food market in Guangzhou, People’s Republic of China. These and similar species, such as the Palolo worm, swarm to spawn, relative to moon phase, allowing for large harvests. From Menzel and D’Aluisio (1998).

Rausch says the species of *Cephenemyia* were also eaten; they, however, were not as abundant and were not considered as much a delicacy.

The Inuit of the Arctic eat the larva of *O. tarandi* also. Ac-

cording to Olayuk Naqitarvik (pers. comm. to Nikolas Konstantinou and George Benz), the Inuit out of Arctic Bay, northern Baffin Island, Nunavut, Canada, also consider the botfly maggots from the hide of caribou to be a special treat (Figs.

15, 16). They reportedly bite off the “heads” and eat the remainder. Presumably, they bite off the posterior spiracle, which superficially appears like a head. The Inuit consider the taste as “sweet.”

Eating botfly maggots is very little different from eating non-parasitic insect larvae, which is common practice in many parts of the world. Because of inherent dangers of toxins and disagreeable taste, the insect larvae eaten by different peoples are typically geographically restricted to select species.

One type of larva that takes little preparatory effort by the central desert aboriginal tribes of Australia (Fig. 17) consists of a variety of caterpillars in the genus *Cossus* called “witchitty worms” (Fig. 18). Comprising the most popular and widely distributed of dietary insects in Australia, the grubs of these giant moths live in the roots of cassia and certain acacia shrubs as well as the trunk and large limbs of a eucalyptus. The adept gatherer locates the worms with a special hooked stick or crowbar. Some species grow up to 10 cm in length, but all can be tossed on hot ashes for a short period until the larva elongates and expands (Fig. 19). The larva is then quickly eaten in the slightly cooked state, if not eaten raw. The taste has been described as delicate and nutty, resembling scrambled eggs and roast pork; according to the rare European taster, it can be compared to a tender oyster (Taylor, 1975; Isaacs, 1999).

In Botswana, for example, the mopane worm (*Conimbrasia belina*), a caterpillar that provides 3 times the protein content of beef by unit weight when dried, serves as a favorite. Before boiling the “worm” with salt and water until the water evaporates, the preparer squeezes out and discards the liquid guts. After being cooked for about 30 min, the worms are spread out to dry in the sun, a process that requires continual turning for about a day (Menzel and D’Aluisio, 1998). Abundant on the mopanie fodder tree during a rainy period, the larva encourages significant commercial production. Preparation consists of squashing the larvae, allowing them to dry, and then roasting them. Sold by the sack, they are added to stews. The Pedi of South Africa would prefer a quarter pound of these to a full pound of fresh beef (Taylor, 1975).

In the lush forests of Ssese Islands in Lake Victoria of Uganda, palm grubs, or worms (“masinya,” *Rhynocophora palmarum*) from dead moriche palm trees serve this need. Once again, the intestine is removed; the grubs are sautéed in their own oil along with salt, curry powder, and onions. This is a prized favorite of the locals (Menzel and D’Aluisio, 1998). The related sago beetle grubs (*Rhynchophorus ferrugineus*) from the Asmat Swamp, perhaps the world’s largest swamp, in Irian Jaya, the Indonesian half of the island of New Guinea, constitute a dinner rather than simply a delicacy (Fig. 20). Lightly sautéed, they emitted a delicate aroma and tasted like creamy snail (Menzel and D’Aluisio, 1998). Other New Guineans even fell the palms, cut holes in the trunk to allow entrance for the beetle, and harvest large numbers after about 6 wk for a “grub-festival ceremony,” usually linked with a marital relationship (Taylor, 1975).

In the United States, crickets are a favorite. Some Native Americans apparently have long enjoyed the Mormon cricket (*Anabrus simplex*), even though different native tribes have favored or depended on other insects. Gordon (1998) reports a relevant quotation: “‘I have seen the Cheyennes, Snakes, Utes, etc., eat vermin off each other by the fistful,’ wrote the nine-

teenth-century chronicler Father Pierre-Jean de Smet. ‘Often great chiefs would pull off their shirts in my presence without ceremony, and while they chatted, would amuse themselves with carrying on this branch of the chase in the seams. As fast as they dislodged the game, they crunched it with as much relish as more civilized mouths crack almonds and hazel-nuts or the claws of crabs and crayfishes.’” Peterman’s HotLix company in California has taken advantage of interest in eating crickets with the “Cricket Lick-it,” a sugar-free lollipop flavored with crème de menthe (Menzel and D’Aluisio, 1998). When U.S. products are advertised as “worms,” they usually consist of a mealworm product, such as candied apples with worms as prepared by HotLix Candy Company (Fig. 21).

An effort on the part of some groups in North America has encouraged the practice of eating insects. Gordon (1998) provided a list of sponsors of bug-eating events. One of those, the Montréal Insectarium, provides “insect tastings” and other activities involving entomophagy. One activity included serving an advertised 100,000 mealworms (Fig. 22) and many other insects incorporated into a long list of gastronomical delights (D. Marcogliese, pers. comm.). One such devotee, our chairman of the Halifax meeting’s Local Organizing Committee (D. Cone, D. Strongman, pers. comm.) enjoyed a plateful of deep-fried tarantulas in the bus station near Phnom Penh, Cambodia (Fig. 23). The spiders were collected by children from the local rice fields.

Simonetta Mattiucci (pers. comm.) told me about “cheese with worms” from Sardinia, Italy, but she pointed out that the “worms” were not parasitic worms but fly larvae with the potential to cause internal miasis in those who ate it. Consequently, the dish should be avoided.

In a search to find more about these maggots, I obtained conflicting stories about “casu marzu.” Perhaps there are different products because it is produced in northern Italy’s Piedmont and Bergamo areas as well as in Sardinia, where it is most well known; a large amount is spread onto folded thin Sardinian brown bread sprinkled with water to make folding easier. In all areas, it is served at the end of a meal with a full-bodied red wine. But because of its illegal nature, it is either sold on the black market or served at homes to relatives and friends and usually not at commercial establishments. The product is typically made with pecorino, a hard sheep milk cheese. The cheese fly, *Piophilidae casei*, lays eggs in the cheese, and its larva promotes fermentation, allowing the fats to decompose and leaving a pungent goo that burns the tongue. Casu marzu is also produced with a goat milk-based soft cheese produced by farmers from the southeastern Piedmont mountains permeated with pale pink, small, fat, barrel-shaped maggots crawling throughout the cheese.

A different European product utilizes not flies but the cultured cheese mite, *Tyrophagus casei*, which is capable of causing dermatitis, introduced to German Altenburger cheese. The mite-infested product becomes covered by a gray powder, which consists of the mites, their molts, and their feces. Whether the flavor results from a fly or a mite, the product is moving with the visible wriggling animals; numerous people enjoy it, and large quantities are eaten.

Digeneans (flukes): In addition to obtaining edible parasites from shrimp products, one can find examples among many other “shellfish” and other invertebrates. One is the eastern oyster

(*Crassostrea virginica*) or related bivalves infected with bucephalid digeneans. That group of digeneans asexually produces sporocysts, with those of a few species (but not the oyster) causing a discoloration of the edible "meat" of the product. When the parasite infects the gonad of its bivalve host, the host often diverts its energy into growth rather than reproduction, producing an enlarged edible portion. Menzel and Hopkins (1955) indicated that "In southern waters, normal oysters spawn so heavily and so long that they become emaciated and nearly tasteless by late summer, but *Bucephalus*-infected oysters, being castrated or 'caponized,' remain fat and retain an excellent flavor all summer. Personal tests have proved that the *Bucephalus* sporocysts taste even better than the oyster."

The giant liver fluke of deer (Fig. 24), up to 8 cm long, represents well a widespread example of an edible digenean, primarily because of its large size. William Font (pers. comm.) tells about an undergraduate student (Tony) at University of Wisconsin Eau Claire, who, when dissecting the livers of white-tailed deer brought in by the student hunters during the middle of deer season, spoke about old timer deer hunters in northern Wisconsin who considered the best part of eating deer was eating the "little livers." Individuals of the giant liver fluke, *Fascioloides magna*, of white-tailed deer, mule deer, elk, and other herbivores of North America and northern Europe constitute the livers inside the livers. The fluke occurs in pairs or in some cases 3 or more in fibrous capsules in the liver parenchyma. Even though seldom is there much inflammation, the blood vessels in the capsule wall intercept the many small bile ducts that penetrate the walls. Hematin pigment from the partial digestion of host blood by the digenean in or on the mesentery, lymph nodes, hepatic tissues, and other organs typically allows one to know that a liver is infected. Usually fewer than 30 occur per deer but as many as 125 have been recorded (e.g., Foreyt, 1981).

I have heard from different sources about the Cajun practice of eating the deer flukes in Louisiana. I recollect hearing about 30 yr ago that the flukes were double fried to produce a puffy specialty like pommes soufflés, or "puffed potatoes," from Arnaud's, Antoine's, and Galatoire's restaurants in New Orleans or like beignets in carefully temperature-controlled cooking oil. Upon trying to get recent confirmation of this from Cajuns in Mississippi and Louisiana, I was unable, suggesting the custom was probably quite local and maybe no longer practiced. Nevertheless, the custom is apparently widespread, even though the recipes differ. The same recipe, however, may have been used to produce puffed-up "sweet meat" from Georgia where Elon E. Byrd told students and colleagues about the hunters frying and eating the delicacies. Other anecdotal stories include those of Native Americans in the Southeast preparing them as "little flapjacks." In any event, a scattering of people eat the fluke, and there is no documented case of this species infecting a human (Beaver et al., 1984).

To transfer the "life force" from 4-hooved prey to human hunter, elderly Lakota Sioux from the Rosebud Reservation in Nebraska and the older generation Sioux elsewhere throughout the Sioux Nation eat a portion of the liver of their game or of butchered domestic animals. They follow this practice with a careful inspection for large flukes such as *F. magna*, *Fasciola hepatica*, and apparently dicrocoelids. Typically, they cook the

worms along with their eggs for breakfast (D. Holiday, pers. comm.).

In Asia, Africa, and Hawaii, the related *Fasciola gigantica* and *F. hepatica* are known from humans (Beaver et al., 1984), but most of these cases apparently result from people eating watercress or other vegetation infected with the encysted metacercaria. Ingesting infected liver typically produces "false fascioliasis," the diagnosis for which is the elimination of eggs from patients' feces following 3 or so days of a liver-free diet (Beaver et al., 1984).

As indicated, eating liver flukes has not been restricted to Americans. In Algeria, a liver fluke of cattle attaches temporarily to the throat of some that eat the liver raw, apparently from sacrificial animals, and these are called "halzoun" or "parasitic laryngo-pharyngitis," an acute irritation (Chandler, 1955). Chandler also mentioned that Wittenberg thought that the agent was a large metacercaria of *Clinostoma* from improperly cooked fish. Perhaps both are true.

Various native peoples relish paramphistomes. For example, local tribes of Meghalaya, a northeastern state of India, favor *Gastrothylax crumenifer*, *Fischoederius elongatus*, *Fischoederius cobboldi*, *Calicophoron calicophorum*, *Paramphistomum epiclitum*, and *Orthocoelium* sp. from the rumen of cattle and buffaloes (Tandon and Roy, 1990). These 2 authors examined the digeneans for 10 heavy metals using atomic absorption and discovered significant amounts of iron and potassium, especially in *G. crumenifer*, an 11- to 18-mm-long species (Sey, 1991). Young boys in a Calcutta, India, abattoir also collected large amphistome specimens, probably some of the same species indicated above, from domestic herbivores and fed them to chickens (Sey, 1991), but apparently the boys did not eat the worms.

An important point is that the natives of various regions understand their surroundings and wildlife. They know they are eating parasites, and they are not repulsed. Members of some tribes, however, may not know they are eating parasites. For example, John Grandage, presently of Murdoch University in Perth, Western Australia, related to Colin Dobson (pers. comm.) that he was on a survey in Uganda that involved killing a hippopotamus. The East African assistants would pull paramphistome digeneans off the stomach lining and eat them raw as "the juicy part of the hippo." Based on the site, geographical locality, and size, the species was probably *Buxifrons buxifrons*, but there could have been a combination of other species since the hippopotamus in Africa hosts 23 additional amphistomes in 8 genera that are specific to it (Sey, 1991). There are 2 issues here: first, John had to fight off the natives to acquire any samples of the amphistome, and second, the natives considered the worms as part of the stomach, the most "juicy" part, rather than a parasite.

Cestodes (tapeworms): Of all the parasites intentionally eaten by people, cestodes constitute the most eaten group. When most parasitologists think of a cestode plerocercoid in fish flesh, they probably think of the pseudophyllidean *Diphylllobothrium latum*. Eating this parasite has an obvious public health risk, so, if seen, it is not eaten. Moreover, fish containing it are typically cooked. There, however, exist several others, such as trypanorhynchian plerocercoids in marine and estuarine fishes that mature in elasmobranchs and are safe to eat. One of these, *Gymnorhynchus gigas*, in the flesh of the Atlantic pomfret, or

Ray's bream (*Brama brama*), according to some Portuguese, causes that infected fish to be tastier than the noninfected counterpart (D. Gibson, pers. comm.). From a different point of view, I have heard from ichthyologists (e.g., C. Richard Robins, previously of the University of Miami, Rosenstiel School of Marine and Atmospheric Science) that seafood consumers distinguish the swordfish (*Xiphias gladius*) from the less-desirable shortfin mako shark (*Isurus oxyrinchus*), often sold as swordfish, by the discoloration, which in turn results from an unknown-to-them trypanorhynchean infection in the swordfish. Infected swordfish steaks are apparently considered tastier than the shark or uninfected swordfish, but the consumer does not recognize the reason for the discoloration. I have seen several instances where 1 of a few different trypanorhynchean species has degenerated, making any specific diagnosis difficult.

There are many embedded, flesh-infecting trypanorhyncheans that do or should make delicious flavor buds. For example, *Pseudogrillotia pleistacantha* in the black drum (*Pogonias cromis*) comprises 1 of these (Fig. 25). Unfortunately, the infection, typically with 5–15 of these 14-cm-long “spaghetti worms,” repulses many who see it. In fact, the infections are restricted to the caudal region of a black drum that is larger than 68 cm (Overstreet, 1977), and many seafood consumers will discard infected fish or eat only the smaller fish (Overstreet, 1978).

An educational example addressing the U.S. public's view on trypanorhynchean infections involves a survey on *Poecilancistrum caryophyllum* from the flesh of the spotted seatrout (Figs. 26–28) and related fishes from the Gulf of Mexico (Overstreet, 1977, 1983). At local fishing rodeos, I initially had attendees fill out a prepared questionnaire, but later, using discretion, I asked them additional carefully worded questions depending somewhat on initial answers, and I personally wrote down their comments. These fishing rodeos, events showing off catches of fish, presenting awards, and providing participants and visitors food, music, and games, attract people who enjoy fish. Non-fishers exhibited more disgust at “wormy trout” than fishers or they were not aware the fish were infected. Of 121 people who caught between 30 and >2,000 seatrout per year, 44% saw the worm and did not mind its presence, even though some culled them from the tissues and all cooked the product. Expectedly, 31% were not aware of any worms, either because they did not fillet the fish or more often because they thought the worms were a normal tissue of the fish. However, the remaining 25% knew the fish were infected and would not eat them. Of those fishers that caught fewer than 30 seatrout per year, some specifically did not fish for seatrout because of *P. caryophyllum*. Personally, I think the plerocercoid in the flesh is quite tasty, even more so than the fish, and I like seatrout! I did not make this aspect part of my questionnaire to see how many agreed because I did not want to discourage those people that did not know about the infection from eating seatrouts or other fishes. I did not want them to learn from my survey that the flesh of spotted seatrout and many other local fishes was infected with tapeworms and other parasites.

A similar behavior involves plerocercoids of proteocephalideans and other groups. During hot dry years in the midwest United States, when the water levels are low, an abundance of plerocercoids, at least of a proteocephalid, in the flesh of bullheads, other catfishes, and perches reaches high levels. Local

farmers catch these fish and skin them to eat. The worms are readily apparent in the flesh, usually in nodules. A portion of the fishers eat the worms or infected tissue as a delicacy, usually cooked, while others cull out the worms or discard the entire fish (D. Holiday, pers. comm.).

Different ethnic groups eat the pseudophyllidean plerocercoid of *Ligula intestinalis*, a large metacestode from the body cavity of cyprinids, and a few other fishes. The species typically matures in gulls of at least Europe, Asia, and North America, but it also infects some ducks and grebes. It has a dramatic plerocercoid, well developed and ready to mature quickly in the bird host. Specimens usually measure 10–100 cm long by 6–15 mm wide, although a fisherman brought Barysheva and Bauer (1957) a 1.4-m-long individual from a 38-cm-long Baltic vimba, *Vimba vimba*. Titova (1957), studying infections in the carp bream, *Abramis brama*, determined that the worm grew about 10–13 cm a year and could live up to 5 or 6 yr, with an average age of 3 yr. The fish can reach 82 cm and live up to 17 yr (www.fishbase.org/search.html). Most fish, especially small species, contain 1 or 2 plerocercoids in the body cavity but more than 10 have been seen (Dubinina, 1966). In the northern United States, the worms are relatively small because they infect small cyprinids (Fig. 29), but a few would still make a good meal.

These worms, easy to detect because of the swollen ventral portion of the host's body, are typically roasted or otherwise cooked. Thaddeus Graczyk (pers. comm.) related to me that people in Poland cooked specimens in a skillet, frying them on both sides. He also told me that he did not try them. They, according to the late Paul Beaver as well as lectures by Martin Ulmer, are or were also eaten in northern Italy and elsewhere throughout the Mediterranean area as “vermicelli vicente” (=living spaghetti) and were therefore probably the cestode called “noodles” by some. “Living spaghetti” was eaten raw by fishers in the Caspian Sea. As soon as they caught an infected fish, they would cut into the body cavity, remove the large plerocercoids, and immediately eat them (as read by Sherman Desser, University of Toronto, but neither of us could locate the article).

These plerocercoids have an abundance of food reserves that probably makes them especially nutritious as well as tasty. Some adult and juvenile cestodes temporarily can store as much as 20 to >50% glycogen, measured as dry weight. Lipid can account for 20% of the total worm and >30% dry weight of the parenchyma in gravid proglottids (Roberts and Janovy, 2000). Whether this fat is what makes them so tasty is unknown, but it may be the combination with the glycogen. Since plerocercoids of *L. intestinalis*, other species of *Ligula*, and the related *Schistocephalus solidus* reach an advanced stage of development in the intermediate host and develop to adults quickly when within the definitive host, they also serve as good examples to study in vivo as well as culture in vitro in a medium lacking organic nutrients (e.g., Rogers, 1962).

On the other hand, consumers may undergo some risk when eating *L. intestinalis* raw. Dubinina (1966) discussed the relationship between the lag of the reproductive organs in infected fish and toxic effect on the gonadotrophic function of the fish hypophysis. Pregnant women probably should not eat uncooked plerocercoids. On the other hand, maybe the stomach acid inactivates the compound.

Ethnic groups also eat other pseudophyllideans, including adult worms. According to Robert Rausch (pers. comm.), some of his Inupiat friends told him that coastal groups in Wainwright or Barrow, the northernmost area of Alaska, ate worms still in the intestine of their host. The 2 common abundant species of *Diphylobothrium*, *Diphylobothrium cordatum* and *Diphylobothrium lanceolatum*, in the bearded seal (*Erignathus barbatus*) are cooked along with the intestine. I can only imagine this would be an extremely tasty dish. Some Italian connoisseurs take advantage of consuming the very upper section of the small intestine of a yearling calf or lamb that is still feeding on its mother's milk. Tied off with serosal twine into 15-cm strips, it contains digested mother's milk and a few partially digested bits of grass but apparently no parasites; it is called "paiata" or "pajata" (S. Mattiucci, pers. comm.).

Anoplocephalid cyclophyllideans constitute a group of cestodes that have even greater dietary appeal than pseudophyllideans. They are especially prized in Southeast Asia and exemplify one of the parasite groups eaten by native peoples of New Guinea. There are several different native tribes in Papua New Guinea and adjacent areas, and members of these tribes have a variety of customs or rituals (rituals may occur once a year at a certain time or involve a number of religious ceremonial events) involving parasites. As already reported, social grooming seems to be more than a custom; it seems to have an evolutionary component, and examples of social grooming for arthropods as indicated above are common in many of the New Guinea peoples.

An hors d'oeuvre considered a delicacy among the Atbalmin people of the high and mossy Star Mountains in the western part of Papua New Guinea abutting Irian Jaya is a thick and yellow tapeworm from the intestine of possums. Tim Flannery, who wrote *Throwim Way Leg* (1998), meaning "hit the road" in Melanesian pidgin, a language spoken in Papua New Guinea, was interviewed about "The strangest 'meals' I've ever eaten" (www.familyhaven.com/travel/melanesianman.html). During that interview, he indicated that a slight preparation of the worm was necessary, "You simply wipe the clammy beast between your fingers and pop it in your mouth." In his book, however, Flannery (1998) indicated that the young stepson of his native collecting assistant would turn the stomach of residents and scientists alike when he would pierce his fingernail into the intestine of a coppery ringtail possum (*Pseudocheirus cupreus*, also listed as *Pseudochirops cupreus*). He would open the intestine where a lump existed to allow the tapeworms to squirt out, remove the feces from the worms, and drop each writhing organism straight into his mouth. Concerned that the worms might be harmful to the boy, Flannery sent some specimens to Ian Beveridge, who named the species *Bertiella flanneryi* and assured him that because of the highly specialized gut of the possum, the worm would find the human intestine quite hostile. Two edible species of anoplocephalids actually occur in the possum rather than 1, and both are probably eaten, with the former described as up to 12 cm long and the second (Fig. 30) reaching 43 cm long and therefore named *Bertiella esculenta* (with the Latin "esculenta" meaning good to eat) by Beveridge (1985). Perhaps as an attempt to impress Nicole Thurgate (pers. comm.), a Binum tribesman west of the Kiwari River took a large cestode from a recently caught tree kangaroo and tossed it on 1 of the hot rocks surrounding the fire before eating it.

That cestode was probably an anoplocephalid species of *Progamotaenia*, a few of which are presently being described or discussed by Beveridge (pers. comm.).

This practice of eating worms by different peoples of New Guinea is not all for shock value. It was investigated in much more detail by Peter Dwyer (pers. comm.) and colleagues. In their studies of the ecology of peoples from the Southern Highlands, Eastern Highlands, and coastal areas, Dwyer and Plowman (1981) determined that the possum (*P. cupreus*) and several other marsupials hosted several helminths that were eaten by local people. Those people in the Southern Highlands ate a diet highest in protein, approximately 15 g per person per day, and, in contrast, the coastal people ate the least, 4 g for women and 9 g for men (Dwyer, 1983). Surprisingly, the Etolo population of about 500 in the Southern Highlands—with their high dietary protein, including reared pigs and beetle larvae as well as wild fish, frogs, lizards, and mammals—also ate cestodes and parasitic nematodes. The nematode, an onchocercid species of *Breinlia* (see Spratt et al., 1991), up to 20 cm long, from the body cavity of the coppery ringtail possum and called "efe noi" (translated as "string removed"), was stretched out and eaten raw or cooked. The cestodes, with some reaching 50 cm or longer in length and called "fifi" (unknown translation), were obtained by stripping the entrails prior to cooking. After being wrapped in leaf packages, the cestodes were cooked in an open fire.

In addition to eating cestodes from the ringtailed possum, the natives most certainly ate cestodes from a variety of other select marsupials. Dwyer and Plowman (1981) witnessed the Etolo eating worms from that possum that had been in leaf packages. They also saw fresh leaf packages projecting from the body cavity of recently prepared possums after the entrails had been stripped. They assumed helminths were also eaten from individuals of specific other marsupials that had similar leaf packages projecting from them. Those animals consisted of the tree kangaroo (*Dendrolagus dorianus*), cuscuses (*Phalanger vestitus* and *Phalanger carmelitae*), and the bandicoot (*Peroryctes longicauda*). According to Beveridge (pers. comm.), the presumed cestodes in the kangaroo are *Progamotaenia* spp., in the cuscuses are species of *Bertiella* or related anoplocephalids different from those in the possum, and in the bandicoot are hymenolepids in the genus *Potorolepis*. Individuals of *Ascaris suum* from pigs were always discarded, and no leaf packages were found in any of the many individuals of the 7 large rodent species, which contained nematodes. Dwyer and Plowman (1981) assumed that even though the internal parasites were probably highly nutritious, the Etolo people did not need to supplement their diet, so they presumably regarded the parasites as delicacies. In contrast, the Rofaifo of the Eastern Highlands, who called the nematodes and cestodes from the mammals such as the ringtailed possum "hevali," did not eat these same parasites. Nevertheless, a variety of peoples from other areas eat these and related parasites. For example, Zschokke (1899) named *Bertiella edulis* (Latin for "edible") from the cuscus *Aelurops ursinus* in the Celebes because, as he stated, it was sought after and eagerly eaten by local natives; a second related species, *Bertiella sarasinorum*, probably was eaten also, but that point was not specifically indicated (I. Beveridge, pers. comm.). In regard to the potential health risk from eating species of *Bertiella*, *Bertiella studeri* from primates in the Indo-

Pacific and nearby regions and *Bertiella mucronata* from primates in Latin America, both have been reported to infect humans, but these infections by these species were presumably acquired from accidental ingestion of oribatid mites (e.g., Feldman et al., 1983; Beaver et al., 1984; Denegri et al., 1998).

The technique of leaf packets is not restricted to wrapping parasitic worms. The older children of the Dani people of Irian Jaya, gardener-warriors and former headhunters, like to eat spiders as their delicacies and pass stinkbugs down to the younger ones. Menzel and D'Aluisio (1998) reported that a fistful of 20 of these in uneaten leaf packages (bug packages) roasted along the edge of a wood fire make a good snack (Figs. 31–33). The authors said the bugs tasted better than some of the “worms” they tried.

The extremely large tapeworms *Moniezia expansa* and *Moniezia* spp., anoplocephalids related to *Bertiella* spp., eaten by native peoples of New Guinea and other areas commonly infect domestic sheep, goats, and cattle in large numbers. One or more of these species are also eaten by some people, including those in northern Italy, but I do not know the details. According to Colin Dobson (pers. comm.), “*Moniezia* pie” was fried by the farmers and served as a delicacy. He had also heard about the tapeworm being eaten as spaghetti. Whether the same or other cestodes are or were the ingredient(s) of “tapeworm soup,” also supposedly eaten by some Europeans, remains unknown to me. When I asked for confirmation and details of these customs with the Italian parasitologists Simonetta Mattiucci and Lia Paggi, neither was familiar with them. Perhaps these delicacies are enjoyed in isolated communities only or maybe they are no longer eaten.

Another cyclophyllidean, 1 of the most harmful tapeworms of humans, is the pork tapeworm, *Taenia solium*. It has been recognized since the time of Hippocrates (460–375 BC) and possibly of Moses; Aristotle mentioned the larva as occurring in the tongue of swine (Beaver et al., 1984), even though the life cycle did not get worked out until later (Küchenmeister [1855] and Leukart [1856] as cited in Beaver et al., 1984).

Humans get the adult stage of *T. solium* in their intestine, usually after eating pork with infective cysticerci in the muscle. The adult usually causes only slight irritation at the site of attachment but infrequently can cause obstruction and discomfort. However, harmful cysticercosis infections in most organs and tissues may be acquired by ingestion of eggs in contaminated food or water, self-contamination from an adult infection, or internal autoinfection from reversed peristalsis carrying eggs (Beaver et al., 1984).

Pork infected with the cysticercus, also termed “measly pork,” is considered by some to be more tasty than uninfected animals, at least when cooked. Presumably because of the improved taste, there have been times in Mexico when pork flesh infected with *T. solium* has gone for a higher price than non-infected meat (E. Foor, pers. comm., from lectures by Harold W. Brown, ASP President in 1960, Columbia University, and Martin J. Ulmer, ASP President in 1977).

Looking at the pork tapeworm from a different point of view, I add here that the interesting book *New Guinea Tapeworms and Jewish Grandmothers* by Robert Desowitz (1981) did not provide readers with the virtues of eating delicious tapeworms. Rather it told of the unfortunate gift of pigs to the Ekari of West New Guinea. The United Nations had directed West New

Guinea in 1969 to decide whether it should join the Republic of Indonesia, and during the change in the regime, the Indonesian government sent pigs and troops from Bali, Indonesia, as appeasement and policing. The Ekari treated pigs as a quasi family member in a godly fashion, eating them as a part of various celebrations, religious sacrifices, and other important events. Whereas the Balinese, who are primarily Hindus, eat pork, they are very careful and seldom acquire infections with the pork tapeworm. The rest of Indonesia, mostly Muslim, does not eat pork. Well, the “gift” unintentionally introduced the tapeworm into the remote area of New Guinea, resulting in a disastrous 25% infection of cysticercosis in Ekari adults and children by 1978.

Species of related cyclophyllideans in the genus *Echinococcus* also have intermediate stages that can infect various tissues in humans or a variety of herbivorous hosts and produce serious disease. Such infection in humans and other intermediate hosts occurs from the host eating eggs rather than from eating the fluid-filled hydatid cysts. These cysts contain large numbers of protoscolices infective to 1 of the corresponding relatively specific carnivorous definitive hosts. Michael Burt (pers. comm.) recalls hearing that the first individual in a hunting party of different South American Indian groups to spear a cervid (the deer family) was given the honor—if the animal had an infection of *Echinococcus* sp.—to drink the fluid from the hydatid cyst.

Nematodes (roundworms): As indicated above, a filarid nematode from the coppery ringtail possum in Papua New Guinea is a component of the native diet, but ascaridoid nematodes and most others are typically avoided.

The reason for not eating ascaridoids probably results from some antigenic and other compounds that can be very irritating or induce a strong immune reaction in sensitive individuals. Pseudocoelomic body fluid from the pig ascaris, *Ascaris suum*, seems to have a strong immunomodulatory activity associated with components other than the putative allergin (Paterson et al., 2002). Extremely large numbers of ascaridoids, however, are eaten unknowingly in cooked or previously frozen products throughout the world daily, and these worms (mostly worms from the complexes of at least 5 species each of *Anisakis simplex* sensu lato and *Pseudoterranova decipiens* sensu lato) seem to have been associated with allergic reactions ranging from skin reactions to anaphylactic shock (Lopata, 2001). This toxic effect is unfortunate because worms such as ascaridoids that do not have ready access to a host's carbohydrate reserves or in which metabolism is predominately anaerobic have large amounts of stored glycogen. Most filaria do not have such a high level of stored glycogen because they depend on the host's blood or tissues that are high in glycogen (e.g., Rogers, 1962). These, on the other hand, are the nematodes of choice for eating.

However, a twist occurs in the rationale for intentionally eating raw ascaridoids. According to Bruce Christensen, the father of a female Laotian student in 1 of his classes indicated to her that some Laotians would wash and eat ascaridoids and cestodes passed in their feces to show others that they were not afraid of them. As a sort of revenge factor to the parasites, similar to the reaction the Hottentots directed toward lice as indicated above, they were suggesting, “We are not afraid of you, we will eat you.”

Miscellaneous animals: A variety of invertebrates that have a wormlike appearance is eaten raw or cooked. Some of these have a symbiotic relation with a host, but the examples below demonstrate similarities in approaches to eating parasites and nonparasites and disgust by others not familiar with those approaches.

Isaacs (1999) presents data on the Arnhem Land Aboriginal people of Australia, who, like other Aborigines, find no relationships among people, plants, and animals that do not also involve the spirit world. Custom, rules, and traditional law determine all practices with gathering, cooking, and eating foods throughout Aboriginal Australia. The same philosophy occurs for "tribal" activities involving food throughout most of the world. Such regulation helps keep diets safe and controls resources that are difficult to obtain.

Even though not parasites, shipworms look like parasites to some. They are not even true worms: they are bivalve molluscs that have shell plates anteriorly, allowing them to drill in floating wood, pilings, and mangrove roots (Fig. 34). Groups around the world eat them as exemplified by an Arnhem girl in the Gulf of Carpentaria, Australia, eating 1 of the 2 commonly eaten species by her people. To collect the worms, they cut into the mangrove roots with a small ax (Fig. 35). Of the 2 species, a small white one must be cooked or it produces a sore throat. In fact, it is the broth from that species that is typically consumed. A pinkish species, up to 30 cm long, is prepared by removing both ends, sucking or milking out the internal organs and discarding them, and then eating the worm whole (Fig. 36). They are considered delicacies (Isaacs, 1999).

The Chinese and other groups of people eat marine polychaetes, typically nereids like the Palolo worms portrayed (Fig. 37) by Menzel and D'Aluisio (1998). The Chinese apparently eat leeches today, even though some of their ancestors believed leeches could live and multiply in one's stomach. An old Chinese superstition held that each particle from a powdered leech could produce a new leech (Hoeppli, 1959). When customers regularly purchased leeches at the International Center for Medicinal Leeches in Rodniki, Russia, the company stopped sales to keep their leeches being eaten at a Peking restaurant in downtown Moscow (Banerjee, 2000).

SUMMARY

Using good sense and some biological information, one can enjoy a delightful morsel or enhanced meal from a variety of parasites, either raw or cooked.

Bon Appétit!

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LITERATURE CITED

- ARCHBOLD, R., AND A. L. RAND. 1940. New Guinea expedition. Robert M. McBride and Company, New York, 206 p.
- BANERJEE, N. 2000. Bloodsuckers of old are poised for a comeback. *Rodniki Journal*. [The New York Times on the web, 12 April 2000.]
- BARYSHEVA, A. F., AND O. N. BAUER. 1957. Fish parasites of Lake Ladoga. *Izvestiya vsesoyuznogo nauchno-issledovatel'skogo instituta ozerogo i rechnogo rybnogo khozyaistva* (All-Union Research Institute of Lake and River Fishery, English translation, 1961, NSF, DOI, and IPST OTS 60-51169) **42**: 171–223.
- BEAVER, P. C., R. C. JUNG, AND E. W. CUPP. 1984. Clinical parasitology, 9th ed. Lea & Febinger, Philadelphia, Pennsylvania, 825 p.
- BEVERIDGE, I. 1985. The genus *Bertiella* (Cestoda: Anoplocephalidae) from Australasian mammals: New species, new records and redescrptions. *Systematic Parasitology* **7**: 241–289.
- BUTLER, P. A. 1954. Summary of our knowledge of the oyster in the Gulf of Mexico. In *Gulf of Mexico: Its origin, waters, and marine life*, P. S. Galtsoff (ed.). Fishery Bulletin of the Fish and Wildlife Service **55**: 479–489.
- CANNING, E. U., A. CURRY, AND R. M. OVERSTREET. 2002. Ultrastructure of *Tuzetia weidneri* sp. n. (Microsporidia: Tuzetiidae) in skeletal muscle of *Litopenaeus setiferus* and *Farfantepenaeus aztecus* (Crustacea, Decapoda) and new data on *Perezia nelsoni* (Microsporidia, Pereziiidae) in *L. setiferus*. *Acta Protozoologica* **41**: 63–77.
- CHANDLER, A. C. 1955. Introduction to parasitology, 9th ed. John Wiley & Sons, Inc., New York, 799 p.
- CHRISTENSEN, A. M., AND J. J. McDERMOTT. 1958. Life-history and biology of the oyster crab, *Pinnotheres ostreum* Say. *Biological Bulletin* **114**: 146–179.
- DEARDORFF, T. L., AND R. M. OVERSTREET. 1990. Seafood-transmitted zoonoses in the United States: The fishes, the dishes, and the worms. In *Microbiology of marine food products*, D. R. Ward and C. R. Hackney (eds.). Van Nostrand Reinhold, New York, p. 211–265.
- DENEGRI, G., W. BERNADINA, J. PEREZ-SERRANO, AND F. RODRIGUEZ-CAABEIRO. 1998. Anoplocephalid cestodes of veterinary and medical significance: A review. *Folia Parasitologica* **45**: 1–8.
- DESOWITZ, R. S. 1981. New Guinea tapeworms and Jewish grandmothers: Tales of parasites and people. W. W. Norton & Company, New York, 224 p.
- DUBININA, M. N. 1966. Tapeworms (Cestoda, Ligulidae) of the fauna of the USSR. Amerind Publishing Company, New Delhi, India, 320 p. [Academy of Sciences of the USSR; 1980 translation from Russian.]
- DWYER, P. D. 1983. Etolo hunting performance and energetics. *Human Ecology* **11**: 145–174.
- , AND K. P. PLOWMAN. 1981. Edible internal parasites from Papua New Guinea. *Search* **12**: 409.
- ELLIOTT, D. E., J. LI, A. BLUM, A. METWALI, K. QUADIR, J. F. URBAN JR., AND J. V. WEINSTOCK. 2002. Exposure to schistosome eggs protects mice from TNBS-induced colitis. *American Journal of Physiology: Gastrointestinal and Liver Physiology* **284**: G385–G391.
- , J. F. URBAN JR., C. K. ARGO, AND J. V. WEINSTOCK. 2000. Does the failure to acquire helminthic parasites predispose to Crohn's disease? *FASEB Journal* **14**: 1848–1855.
- FELDMAN, R. E., G. M. DENEGRI, J. O. AVOLIO, AND N. CANTU. 1983. Nuevo caso humano de teniasis por *Bertiella mucronata* (Cestoda:

- Anoplocephalidae), Meyner, 1895, en la Argentina. 1 Diagnostico y tratamiento. *Acta Bioquimica Clinica Latinoamericana* **17**: 571–578.
- FLANNERY, T. F. 1998. *Throwim way leg*. Atlantic Monthly Press, New York, 326 p.
- FOREYT, W. J. 1981. Trematodes and cestodes. In *Diseases and parasites of white-tailed deer*, W. R. Davidson, F. A. Hayes, V. F. Nettles, and F. E. Kellogg (eds.). Tall Timbers Research Station, Tallahassee, Florida, Miscellaneous Publication No. 7, p. 237–265.
- GARTH, J. S., AND D. P. ABBOTT. 1981. Brachyura: The true crabs. In *Intertidal invertebrates of California*, R. H. Morris, D. P. Abbott, and E. C. Haderlie (eds.). Stanford University Press, Stanford, California, p. 594–630.
- GORDON, D. G. 1998. *The eat-a-bug cookbook*. Ten Speed Press, Berkeley, California, 101 p.
- HAVEN, D. S. 1958. Effects of pea crabs *Pinnotheres ostreum* on oysters *Crassostrea virginica*. *Proceedings of the National Shellfisheries Association* **49**: 77–86.
- HEINZ, H. J., AND G. M. MACNAB. 1965. Cysticercosis in the Bantu of Southern Africa. *South African Journal of Medical Science* **30**: 19–31.
- HOEPLI, R. 1959. *Parasites and parasitic infections in early medicine and science*. University of Malaya Press, Singapore, 526 p.
- INGSTAD, H. 1954. Nunamiut; among Alaska's inland Eskimos. W. W. Norton & Company, Inc., New York, 303 p.
- ISAACS, J. 1999. *Bush food: Aboriginal food and herbal medicine*. Lansdowne Publishing Pty. Ltd., Sydney, 256 p.
- KENNEDY, M. J., AND R. A. NEWMAN. 1986. Synopsis of the parasites of vertebrates of Canada. Alberta Agriculture, Animal Health Division, Edmonton, Alberta, Canada, 109 p.
- KRUCZYNSKI, W. L. 1974. Relationship between depth and occurrence of pea crabs, *Pinnotheres maculatus*, in blue mussels, *Mytilus edulis*, in the vicinity of Woods Hole, Massachusetts. *Chesapeake Science* **15**: 167–169.
- LOPATA, A. 2001. Allergy to seafood in Africa. *Science in Africa* **10**. [Available at: <http://www.scienceinAfrica.co.za>.]
- MAYBERRY, L. F. 1996. Presidential address. *Journal of Parasitology* **82**: 855–864.
- MENZEL, P., AND F. D'ALUISIO. 1998. *Man eating bugs*. Ten Speed Press, Berkeley, California, 191 p.
- MENZEL, R. W., AND S. H. HOPKINS. 1955. The growth of oysters parasitized by the fungus *Dermocystidium marinum* and by the trematode *Bucephalus cuculus*. *Journal of Parasitology* **41**: 333–342.
- MORRIS, D. 1967. *The naked ape*. McGraw-Hill Book Company, New York, 252 p.
- OVERSTREET, R. M. 1973. Parasites of some penaeid shrimps with emphasis on reared hosts. *Aquaculture* **2**: 105–140.
- . 1977. *Poecilancistrum caryophyllum* and other trypanorhynch cestode plerocercoids from the musculature of *Cynoscion nebulosus* and other sciaenid fishes in the Gulf of Mexico. *Journal of Parasitology* **63**: 780–789.
- . 1978. Trypanorhynch infections in the flesh of sciaenid fishes. *Marine Fisheries Review* **40**: 37–38.
- . 1983. Aspects of the biology of the spotted seatrout, *Cynoscion nebulosus*, in Mississippi. *Gulf Research Reports, Supplement* **1**: 1–43.
- PATERSON, J. C. M., P. GARSIDE, M. W. KENNEDY, AND C. E. LAWRENCE. 2002. Modulation of a heterologous immune response by the products of *Ascaris suum*. *Infection and Immunity* **70**: 6058–6067.
- PERKINS, W. L. 1965. *The Fannie Farmer cookbook*, 11th ed. Little, Brown and Company, Boston, Massachusetts, 624 p.
- RAUSCH, R. 1951. Notes on the Nunamiut Eskimo and mammals of the Anaktuvuk Pass Region, Brooks Range, Alaska. *Arctic* **4**: 147–196.
- ROBERTS, L. S. 1999. Presidential address: The cure for all diseases. *Journal of Parasitology* **85**: 996–999.
- , AND J. JANOVY JR. 2000. *Gerald D. Schmidt & Larry S. Roberts' foundations of parasitology*, 6th ed. McGraw Hill, Boston, Massachusetts, 670 p.
- ROGERS, W. P. 1962. The nature of parasitism: The relationship of some metazoan parasites to their hosts. *Theoretical and experimental biology*, vol. 2. Academic Press, New York, 287 p.
- ROMBAUER, I. S., AND M. R. BECKER. 1963. *Joy of cooking*. The Bobbs-Merrill Company, Inc., Indianapolis, Indiana, 849 p.
- RUSSELL-HUNTER, W. D. 1979. *A life of invertebrates*. Macmillan Publishing Co., Inc., New York, 650 p.
- SANDOZ, M., AND S. H. HOPKINS. 1947. Early life-history of the oyster crab, *Pinnotheres ostreum* (Say). *Biological Bulletin* **93**: 250–258.
- SEY, O. 1991. *CRC handbook of the zoology of amphistomes*. CRC Press, Inc., Boca Raton, Florida, 480 p.
- SILAS, E. G., AND K. ALAGARSWAMI. 1967. On an instance of parasitisation by the pea-crab (*Pinnotheres* sp.) on the backwater clam [*Meretrix casta* (Chemnitz)] from India, with a review of the work on the systematics, ecology, biology and ethnology of pea crabs of the genus *Pinnotheres* Latreille. *Proceedings of the Symposium on Crustacea*, Ernakulam, 1965, Part 3. Marine Biological Association of India, Symposium Series **2**: 1161–1227.
- SPRATT, D. M., I. BEVERIDGE, AND E. L. WALTER. 1991. A catalogue of Australasian monotremes and marsupials and their recorded helminth parasites. *Records of the South Australian Museum, Monograph Series* **1**: 1–105.
- STAUBER, L. A. 1945. *Pinnotheres ostreum* parasitic on the American oyster, *Ostrea virginica* (Gryphaea). *Biological Bulletin* **88**: 269–291.
- TANDON, V., AND B. ROY. 1990. Analysis of trace elements of some edible trematodes parasitising the bovine hosts. *Bulletin de la Société Française de Parasitologie* **8** (Suppl. 1): 333.
- TAYLOR, R. L. 1975. *Butterflies in my stomach: Insects in human nutrition*. Woodbridge Press Publishing Company, Santa Barbara, California, 224 p.
- TITOVA, S. D. 1957. The parasitofauna of bream (*Abramis brama*) of Lake Ubinskoe. *Izvestiya vsesoyuznogo nauchno-issledovatel'skogo instituta ozernogo i rechnogo rybnogo khozyaistva* (All-Union Research Institute of Lake and River Fishery, English translation, 1961, NSF DOI, and IPST OTS 60-51169) **42**: 160–170.
- WEINSTOCK, J., AND D. ELLIOTT. 1998. The substance P and somatostatin interferon M immunoregulatory circuit. *Annals of the New York Academy of Sciences* **840**: 532–539.
- WEINSTOCK, J. V., R. W. SUMMERS, D. E. ELLIOTT, K. QUADIR, J. F. URBAN JR., AND R. THOMPSON. 2002. The possible link between deworming and the emergence of immunological disease. *Journal of Laboratory and Clinical Medicine* **139**: 334–338.
- ZSCHOKKE, F. 1899. Neue Studien an Cestoden aplacentaler Säugetiere. *Zeitschrift für Wissenschaftliche Zoologie* **65**: 404–445.