■ Interagency Ecological Program for the San Francisco Estuary ■

IEP NEWSLETTER

VOLUME 16, NUMBER 2, SPRING 2003

Herndon J. 2003. Nitrogen uptake by *Heterosigma akashiwo*: A laboratory and field study. M.A. Thesis, Dept. of Biology, San Francisco State University, San Francisco, CA.

Horner RA, Garrison DL, Plumley FG. 1997. Harmful algal blooms and red tide problems on the U.S. west coast. Limnol. Oceanogr. 42 (5): 1076-1088.

Intergovernmental Oceanographic Commission (IOC), UNESCO, NOAA. 1997. New issues in taxonomy. Harmful Algae News 16: 20-21.

Langlois G. 2002. Marine Biotoxin Monitoring and Preharvest Shellfish Programs, California Department of Health Services. Electronic mail message to W. Cochlan. June 24, 2002.

O'Halloran C. 2002. Department of Ocean Sciences, University of California, Santa Cruz. Phone conversation with J. Herndon. September 27, 2002.

Taylor FJR, Haigh R. 1993. The ecology of fish-killing blooms of the chloromonad flagellate *Heterosigma* in the Strait of Georgia and adjacent waters. In: Smayda TJ, Shimizu Y, editors. Toxic Phytoplankton Blooms in the Sea. Elsevier Science Publishers, Amsterdam, p 705-710.

Throndsen J. 1997. The planktonic marine flagellates. In: Tomas CR, editor. Identifying Marine Phytoplankton. Academic Press, San Diego, p 591-729.

Tyrrell JV, Scholin CA, Berguist PR, Berguist PL. 2001. Detection and enumeration of *Heterosigma akashiwo* and *Fibrocapsa japonica* (Raphidophyceae) using rRNA-targeted oligonucleotide probes. Phycologia 40 (5): 457-467.

Tyrrell JV, Connell LB, Scholin CA. 2002. Monitoring *for Heterosigma akashiwo* using a sandwich hybridization assay. Harmful Algae 1: 205-214.

On Mitten Crabs and Lung Flukes

Andrew N. Cohen (San Francisco Estuary Institute), acohen@sfei.org

Parasitology textbooks have long reported that grapsid crabs in the genus *Eriocheir*, commonly known as mitten crabs, are important second intermediate hosts of the Oriental Lung Fluke, *Paragonimus westermani*, along with several other crab and crayfish species in Asia (e.g., Hegner and others 1929; Chandler and Read 1961; Muller 1975; Cheng 1986; Smyth 1994). Epidemiologic reviews have specifically noted the Chinese Mitten Crab, *E. sinensis,* as an important source of human infection in China and Korea (Yokogawa 1965, 1974; Miyazaki 1974; Choi 1990). Many of these texts include a diagram of the lung flukes' life cycle, often with a drawing of a mitten crab host, to illustrate the passage of digenetic trematodes through multiple host species (e.g., Lapage 1963, p. 154; Miyazaki 1974, p. 104; Kim 1984, p. 1181). Recently, however, some Chinese fisheries experts—including Prof. Zhao, director of the Anhui Weiqing Aquatic Products Company, and Prof. Zhang (retired) of the Shanghai Fishery Research Institute—have said that this commonly-reported association of lung flukes with mitten crabs is incorrect. According to these experts, *P. westermani* does not occur in *E. sinensis* and the true intermediate hosts of the lung fluke are various potamid crabs commonly known as creek crabs (Hymanson *and others* 1999; Wang and Hess 2002). Wang and Hess (2002) suggest that an old translation error may have resulted in a misstatement of the fluke's crab host in western literature, which was then copied from paper to paper. To clarify the matter they recommend examining the early papers describing the lung fluke to determine if there were translation errors, and comparing the range of infection in humans with the distribution of mitten crabs and creek crabs.

Kerbert (1878) described the lung fluke, as *Distoma westermanii*, from the lungs of a tiger in the Amsterdam Zoo, and in 1879 Ringer found it in the lungs of a man from Taiwan. Its crustacean intermediate hosts were unknown until 1915, when Nakagawa, working in northern Taiwan, found that encysted metacercariae of the lung fluke were common in two potamid crabs collected in mountain streams and rare in the Japanese Mitten Crab, *Eriocheir japonicus,* collected from lowland streams.

Higher rates of infection were reported in *E. japonicus* collected from mountain streams in this region in 1955-57, and Kuntz (1969) reported that ten years of investigations by various workers had shown *E. japonicus* to be the main crustacean host in Taiwan. Lung flukes were also commonly found in *E. japonicus* in Japan, where the crab inhabits virtually all rivers and streams, in 1915-16. *Eriocheir sinensis* and various crayfish species were reported to be the fluke's crustacean hosts in Korea in 1916-17 and in northeastern China in 1939. In the 1930s the lung fluke was found in east China in a third potamid crab, and rarely in a fourth, mainly in small, rapidly-flowing mountain streams (Yokogawa and others 1960; Kuntz 1969; Cabrera 1984). A total of 12 decapod species were reported as hosts of *P. westermani* in Asia by 1960, 22 species by 1974, and 46-50 species, representing 19-21 genera in 5 families, by 1999 (Yokogawa and others 1960; Miyazaki 1974; Blair and others 1999).

A review of recent literature yielded one study reporting *P. westermani*'s collection in *E. sinensis* in east China (Li 1989), and several studies reporting its frequent and sometimes abundant collection in *E. japonicus* in Korea, Japan, and Taiwan (Fan and Khaw 1965; Huang and Chui 1966; Kuntz 1969; Miyazaki 1974; Cho and others 1991; Lou and others 1992), although one Taiwan study found the lung fluke common in several potamid crabs and absent from *E. japonicus* (Su and others 1989). Kuntz (1969, p. 122) included a photograph of the crab that he found to be the main host of *P. westermani* in Taiwan and which he identified as *E. japonicus*, which from the photograph is clearly a species of *Eriocheir*. Thus over a period of about eight decades *P. westermani* has been identified in *E. sinensis* by at least a few researchers, and in *E. japonicus* by a considerable number of researchers, including Japanese, Korean, Chinese, and American workers. There is no evidence of gross mis-identification or mistranslation in their publications such that a potamid crab could be mistaken for a mitten crab. In addition, Chinese fisheries experts have received reports of *P. westermani* being found in *E. sinensis* in Canada and Hong Kong, presumably in shipments of live crabs from China (Hymanson and others 1999). It seems clear that the trematode known as *Paragonimus westermani*, which causes pulmonary paragonimiasis in humans, routinely occurs in *E. japonicus* and is at least occasionally found in *E. sinensis* in some parts of northeast Asia.

How then could Chinese scientists working with the *E. sinensis* fishery believe that *P. westermani* does not occur in mitten crabs? It may be that the most common form of *P. westermani* in the Yangtze River watershed and east China, where these scientists work, rarely occurs in mitten crabs. Recent molecular genetic analyses of *Paragonimus westermani* have demonstrated the existence of one relatively uniform population in northeast Asia (Japan, Korea, China, and Taiwan) and one or more genetically distinct population groups in south Asia (the Philippines, Thailand and Malaysia), which may warrant description as separate species (Blair and others 1997; Iwagami and others 2000). Within northeast Asia, cytological studies have documented a sexually reproducing diploid form, a parthenogenetic triploid form[1] (which is more pathogenic to humans), and a rare tetraploid form (Kim 1984; Agatsuma and others 1992; Smyth 1994; Terasaki and others 1995; Blair and others 1997, 1999). The triploid form is primarily found in *E. japonicus* in Taiwan, Japan, and Korea, and is also found in crayfish in Korea and northeastern China (Terasaki and others 1995; Blair and others 1999). The diploid form is reported mainly in potamid crabs and rarely in mitten crabs throughout northeast Asia, and this is the main form reported from the Yangtze watershed/east China region (Li 1989; Blair and others 1999).

Another possibility is that the fishery scientists work mainly with cultured mitten crabs, while the lung fluke may occur primarily in wild mitten crabs in China. Wild mitten crabs have declined in China's larger rivers in recent decades, and mitten crab populations in these rivers now consist mainly of commercially cultured crabs (Hymanson and others 1999), which occupy the low-gradient, lower reaches of these rivers and associated "side lakes," ponds, and rice paddies. Wild mitten crabs persist in smaller coastal streams, where they are typically smaller and shorter-lived (Veldhuizen 2000). Since Kuntz (1969) and Kim (1984) report from their studies in Taiwan and Korea that *P. westermani* is most common in *E. japonicus* in well-oxygenated, flowing waters in hilly or mountainous regions, and Zhang, quoted in Wang and Hess (2002; see also Hymanson *and others* 1999), states that the snail that serves as the first intermediate host of *P. westermani* in China prefers such waters, the wild mitten crabs of lotic waters may be more likely to carry lung flukes than the cultivated crabs in lentic waters.

1. Miyazaki proposed the name *Paragonimus pulmonalis* for the triploid form, but this has not been accepted as a valid species by most workers.

From a U.S. public health perspective, there are two issues to consider: Could mitten crabs imported from Asia carry *P. westermani* to the U.S.? and could mitten crabs established in the U.S. serve as second intermediate hosts, if *P. westermani* were introduced? It appears that either *E. japonicus* or *E. sinensis* (at least from Korea or northeastern China) are potential carriers of *P. westermani*, especially of the triploid form, which is more pathogenic to humans, and which reproduces parthenogenetically and therefore may more easily become established. Both could also serve as second intermediate hosts for the triploid form, probably along with many of the crayfish species already present in the U.S. To the extent that the establishment of *P. westermani* would be a significant public health concern, appropriate cautionary measures should be taken.

References

Agatsuma T, Ho L, Jian H, Habe S, Terasaki K, Shibahara T, Sugiyama H, Kim D, Kawashima K. 1992. Electrophoretic evidence of a hybrid origin for tetraploid *Paragonimus westermani* discovered in northeastern China. Parasitol Res 78(6):537-538.

Blair D, Agatsuma T, Watanobe T, Okamoto M, Ito A. 1997. Geographical genetic structure within the human lung fluke, *Paragonimus westermani*, detected from DNA sequences. Parasitology 115(4):411-417.

Blair D, Xu ZB, Agatsuma T. 1999. Paragonimiasis and the genus *Paragonimus*. Adv in Parasitol 42:113-172.

Cabrera BD. 1984. Paragonimiasis in the Philippines: current status. Arzneimittel Forschung 34 (II)(9B):1188-1192.

Chandler AC, Read CP. 1961. Introduction to parasitology. 10th Edition. New York (NY): John Wiley and Sons.

Cheng TC. 1986. General parasitology. 2nd Edition. Orlando (FL): Academic Press College Division, Harcourt Brace Jovanovich.

Cho SY, Kang SY, Kong Y, Yang HJ. 1991. Metacercarial infections of *Paragonimus westermani* in freshwater crabs sold in markets in Seoul. Korean J Parasitol [Kisaengchunghak-Chapchi] 29(2):189-192.

Choi DW. 1990. *Paragonimus* and paragonimiasis in Korea. Korean J Parasitol [Kisaengchunghak-Chapchi] 28 Suppl:79-102.

Fan PC, Khaw OK. 1965. *Paragonimus westermani* infection in crustacean host, *Eriocheir japonicus*, in Shen-keng District, Taipei County, Northern Taiwan. Chinese Med J 12:381-396.

Hegner R, Root FM, Augustine DL. 1929. Animal parasitology, with special reference to man and domesticated animals. New York (NY): The Century Co.

Huang WH, Chiu JK. 1966. Epidemiologic studies of *Paragonimus westermani* (Kerbert, 1878) and related species in Taiwan (Formosa). II. Seasonal variation in the incidence of *Paragonimus westermani* infection in *Eriocheir japonicus*. J Formosan Med Assn 65:529-536.

Hymanson Z, Wang J, Sasaki T. 1999. Lessons from the home of the Chinese Mitten Crab. IEP Newsletter 12(3):25-32.

Iwagami M, Ho LY, Su K, Lai PF, Fukushima M, Nakano M, Blair D, Kawashima K, Agatsuma T. 2000. Molecular phylogeographic studies on *Paragonimus westermani* in Asia. J Helminthol 74(4):315-322.

Kerbert C. 1878. Zur Trematoden-Kenntnis. Zoologischer Anzeiger 1:271-273.

Kim DC. 1984. *Paragonimus westermani*: life cycle, intermediate hosts, transmission to man and geographical distribution in Korea. Arzneimittel Forschung 34 (9B):1180-1183.

Kuntz RE. 1969. Biology of *Paragonimus westermani* (Kerbert, 1878) Braun, 1899: infection in the crab host (*Eriocheir japonicus* De Haan) on Taiwan. Trans Am Microb Soc 88(1):118-126.

Lapage G. 1963. Animals parasitic in man. Revised Edition. New York (NY): Dover Publications, Inc.

Li YS. A survey of freshwater crabs harbouring parasites in Fujian Province. Acta Hydrobiologica Sinica 13:83-86.

Lou YS, Fujino T, Morita K, Ishii Y. 1992. A comparative ultrastructural and histochemical study of the metacercarial cyst walls of four species of *Paragonimus* (Troglotrematidae: Tremadoda). Parasitol Res 78:457-462.

Miyazaki I. 1974. Lung flukes in the world: morphology and life history. In: Sasa M, editor. Parasitic diseases. Tokyo: International Medical Foundation of Japan.

Muller R. 1975. Worms and disease: a manual of medical helminthology. London (UK): William Heinemann Medical Books Ltd.

Smyth JD. 1994. Introduction to animal parasitology. 3rd Edition. Cambridge (UK): Cambridge University Press.

Su KE. *and others* 1989. The examination of the second intermediate hosts of *Paragonimus westermani*, diploid type, in Taiwan. Japanese J Parasitol 38(4):207-215.

Terasaki K, Habe S, Ho L, Jian H, Agatsuma T, Shibahara T, Sugiyama H, Kawashima K. 1995. Tetraploids of the lung fluke *Paragonimus westermani* found in China. Parasitol Res 81(7):627-630.

Veldhuizen T. 2000. Predictions and predications from a visiting Chinese Mitten Crab expert. IEP Newsletter 13(1):14-15.

Wang J, Hess L. 2002. Do mitten crabs carry the parasitic lung fluke? IEP Newsletter 15(3):14-15.

Yokogawa M. 1965. *Paragonimus* and paragonimiasis. Adv in Parasitol 3:99-158

Yokogawa M. 1974. Epidemiology and control of paragonimiasis. In: Sasa M, editor. Parasitic diseases. Tokyo: International Medical Foundation of Japan.

Yokogawa S, Cort WW, Yokogawa M. 1960. *Paragonimus* and paragonimiasis. Exp Parasitol 10(1):81-137.

Cross-channel Variability in Benthic Habitat

Marc Vayssières and Heather Peterson (DWR), marcv@water.ca.gov

Introduction

Benthic invertebrates play an important role in estuarine food webs and biogeochemical cycling of carbon, nutrients, and contaminants. The generally sedentary benthic invertebrates continuously integrate local water, sediment, and food conditions. This makes them good indicators of the type and quality of aquatic habitat at the location where they are found.

The Interagency Ecological Program's Environmental Monitoring Program (EMP) has monitored benthic invertebrates since the mid-1970s. A recent review of the EMP found that the spatial study design of the benthos monitoring element was in need of a thorough reexamination through intense special studies and extensive historic data analyses. This article reports the results of preliminary analyses of historical EMP data focusing on cross-channel variability. Specific questions are: (1) do benthic habitats and community assemblages vary between positions across a river channel? (2) Are benthic samples taken at a single channel position sufficiently representative of benthos assemblages across the channel to characterize long term changes in the benthos community of a particular section of a river?

Materials and Methods

The EMP has sampled benthic macrofauna (organisms larger than 0.5 mm) at 3 cross-channel positions in the Sacramento River near the confluence with the San Joaquin River (Figure 1) since 1977. The "right", "Center", and "Left" positions were sampled biannually from 1977 to 1979 and monthly from 1980 to 1995, at depth of about 12, 35, and 12 feet, respectively. Benthic invertebrates were counted in three replicate samples collected at each of the three positions. We summarized these counts in terms of benthic organism abundance, species richness, species constancy, and the Shannon diversity index (Shannon 1948). As part of its benthos monitoring component, the EMP also collected sediment samples. Here, we summarize sediment analysis