The Liver Flukes: Clonorchis sinensis, Opisthorchis spp, and Metorchis spp.
The liver and intestinal fish-borne zoonotic trematodes (flukes) are important parasites of
humans and animals and are estimated to infect more than 18 million people, especially in Asia.
The diseases caused by fish-borne liver flukes, clonorchiasis, opisthorchiasis and methorchiasis,
can be severe. Infection with high worm burdens has high impact on health status in endemic
areas; a recent estimation of the effect of liver flukes on morbidity yielded DALY value of
Because fish are a major source of protein and an important export commodity in
western Siberia and South East Asia these diseases are of both economic and public health
concern.
is endemic in southern China, Korea and northern Vietnam, whereas
is endemic in the Lower Mekong Basin, including Thailand, Lao People’s Democratic
Republic), Cambodia and south and central Vietnam.
Opisthorchis felineus
documented in at least 12 countries of the European Union, Belarus, Ukraine, and in Western
Siberia (Russia).
species are widespread, and reported from North America,
Eurasia, and East Asia; however, information on human infections is very limited. The infective
stage for humans, as well for animals, is the larval metacercaria stage present in fish that
matures to the adult stage in the hepatobiliary system of humans and other fish-eating
mammals. A significant feature of the epidemiology of these parasites is their wide definitive
host range, which includes not only domestic animals but also sylvatic mammals such as rodents.
and carnivores. The adult flukes can survive for up to ten years in the host, producing around
200 eggs per day. This results in considerable contamination of the environment. Water
becomes contaminated with fluke eggs from indiscriminate deposition of infected human and
animal excreta, which, if ingested by appropriate snail hosts, are the source of the infective
metacercariae found in fish. While those fecal egg sources associated with household fish ponds
can be addressed by sanitation approaches, the common infection of wild fish from the sylvatic
cycle of liver flukes is not amenable to sanitation interventions.
Further, the snail intermediate host species are diverse and abundant in water bodies. These
features make control of these zoonotic parasites difficult and focuses prevention on human
food behaviors, and mass drug treatment of communities. Procedures to limit contamination of
ponds, lakes, and rivers, with human and animal feces containing liver fluke eggs are limited,
but methods focusing on the education of consumers, farmers, and fishermen will be discussed.
Opisthorchis
spp, and
1.0 Epidemiology of the Disease and Pathogens
Trematode parasites of the genera
Clonorchis, Opisthorchis
commonly referred
to as liver flukes, are transmitted to humans and other mammals by the ingestion of fish.
infected with their larval stages which ultimately come from snails infected due to excreta and
These zoonotic
helminths are of public health concern because of the serious pathology they can induce in the
to the Food and Agriculture Organization and the World Health Organization (
life cycles require intermediate hosts that are aquatic (snails and fish) infected due to excretion
eggs of this parasite from feces of infected humans and other mammals
they may,
especially when associated with aquaculture systems, be a consideration in the design of
sanitation systems for human and animal excreta.
1.1 Global Burden of Disease
1.1.1 Global distribution
Figure 1 shows the distribution area of
in western Siberia and Europe and
Figure 2 shows the distribution areas of
Opistorchis viverrini
Cambodia, China, Laos, Thailand and Vietnam
Figure 1. Distribution area of
Information on the distribution of
in western Siberia originated from
Information on the distribution of
O. felineus
distribution area in China (}
and Vietnam (
distribution area in Vietnam (red) (}
Rough distribution area of
in Cambodia, Laos and Thailand (stripped red).
Clonorchis sinensis
Infection with
C. sinensis
and the disease it causes, clonorchiasis, occurs primarily in East Asia,
where it is widely distributed; it is currently endemic in South Korea, China, Taiwan, northern
Vietnam, and eastern Russia
The number of people infected in this region is estimated
to be 7-15 million ( 
and prevalence varies widely, from...
1.0% in Guang Xi, China to > 40% in North Vietnam, to >70% in Guangdong Pr., China.
Importantly,
calculated that 1.1 million of infected people had heavy
infections (> 1000 eggs/gram feces).
Infection with
and the disease it causes, opisthorchiasis, occurs in Cambodia, Lao
PDR (mainly southern areas), Thailand (mainly northeast areas), and southern Vietnam ( 
Doanh and Nawa,
The number of people infected in these countries is estimated to be eight million.
Thailand and two million in Laos
are available in Vietnam even if the presence of
O. viverrini
infection in humans has been
Doanh and Nawa,
Opithorchis felineus
Infection with
O. felineus
and the disease it causes, opisthorchiasis, occurs in Byelorussia,
Kazakhstan, Russia, Ukraine and Siberia, and in scattered foci of the European Union.
(Germany, Greece, Italy, Poland, Portugal and Spain)
In Russia, Ukraine,
and Kazakhstan, 12.5 million people have been considered to be at risk for
O. felineus
In these foci, both humans and domestic animals (cats and dogs) play the
In the Tomsk region of Siberia, the prevalence of
opisthorchiasis in humans increased from 495 cases per 100,000 inhabitants to 649 cases per
100,000 inhabitants between 1997 and 2006 (}
Other endemic foci of
in Siberia are the Ob river and the Irtysh river basins.
1.1.1.4 Trade impact
The liver flukes are ranked 6th among 24 food-borne parasites for impact on trade in endemic
countries; their impact on overall socioeconomic wellbeing of affected communities is ranked
An important factor affecting the evaluation of trade impact of liver
flukes is that their primary source are wild-caught freshwater fish rather than fish produced in
aquaculture (see Section 1.3.2). Further, non-intensive aquaculture farms generally produce for
local domestic markets rather than for international trade. However, in Italy, wild tenches
fished from central Italy lakes, where
is highly endemic, are exported to several fish
markets outside the country and have caused opisthorchiasis outbreaks.
1.1.2 Symptomology
In general, all the liver fluke infections induce chronic inflammatory diseases of the...
hepatobiliary system and in chronic high worm burden infections this may lead to bile duct
cancer termed cholangiocarcinoma (CCA) (}
Pakharukova and
Most of these manifestations are mild and asymptomatic.
However, once advanced CCA develops, clinical manifestations such as jaundice occurs in
approximately half of the cases, while the other half may have no specific symptoms.
Infections with less than 100 worms may be asymptomatic (
Infection with one-hundred to thousands
of worms, however, may cause jaundice, indigestion, epigastric discomfort, anorexia, general
malaise, diarrhea, and mild fever (}
Over time, without treatment, infection...
may lead to liver enlargement, allergic lesions, congestion of the spleen, bile stone
development, cholecystitis, and liver cirrhosis. The most serious possible outcome, however, is
the development of CCA. Benign hepatobiliary diseases are characterized by cholangitis,
obstructive jaundice hepatomegaly, periductal fibrosis, cholecystitis, and cholelithiasis
1.1.2.1 Morbidity and mortality
Because of the potentially severe consequences of all liver fluke infections (e.g., hepatic lesions,
cholangitis, and, most seriously, CCA), chronic infections with high worm burdens have a high
impact on health status in endemic areas; a recent estimation of the effect of clonorchiasis on
morbidity yielded DALY value of 275,370
a relatively high impact for a
helminthic disease. In highly endemic foci of
O. felineus
in Western Siberia, CCA was detected
in 77% of patients with opisthorchiasis, versus 34.2% of patients without opisthorchiasis.
1.2 Taxonomic Classification of the Agents
The fishborne liver flukes of public health importance belong to the trematode family.
The most prevalent and important species are...
O. felineus
members of the subfamily Opisthorchiinae.
These species are similar in morphology, life cycles, and modes of transmission, which often
causes difficulties in specific diagnosis. Their geographic distributions are basically allopatric,
however. Other species of the
genus have been reported from humans only rarely
and will not be considered further in this chapter.
1.2.1 Physical description of the agents
Clonorchis sinensis
The adult worms are flat, elongated, leaf or lanceolate shaped, generally
8-15 mm in length, and 1.5-4.0 mm wide (}
As shown in Figure 3,
is morphologically similar to
Opisthorchis viverrini
O. felineus,
The larval stage transmitted
through fish to humans and other mammals is termed a metacercaria, which is encysted in
various tissues of the fish host. The metacercaria is round to oval, measuring 0.13-0.14 x
Figure 3. Hematoxylin and eosin stained adult worms of the most important liver
Opishorchis felineus
Clonorchis sinensis
scale bar 2 mm. There is no proportion between worm
Figure 4. First intermediate host of liver flukes, and infecting stages for fish.
mammals.
sp., major snail host of liver flukes, scale bar 8 mm; 2
Opisthorchis felineus
cercaria, the swimming larval stage of liver flukes infecting fish,
3, metacercaria of
Clonorchis sinensis
metacercariae of
Opisthorchis viverrini
and 5 metacercariae of
Opisthorchis felineus
permission obtained from Dr. Edoardo Pozio,
The adult worms are flat, elongated, leaf or lanceolate shaped, generally
5.5-10 mm in length, and 0.8-1.6 mm wide (Figure 3)
metacercaria is round to oval, measuring 0.19-0.25 x 0.15-0.22 mm in size (Figure 4).
The adult worms are flat, elongated, leaf or lanceolate shaped, generally
7-12 mm in length, and 1.5-2.5 mm wide (Figure 3)
The metacercaria is
oval, measuring 0.25-0.30 x 0.19-0.23 mm in size (Figure 4).
Variation in the size of adults depends on the intensity of infection and the diameters of the bile
ducts they inhabit.
This genus
belongs to a separate opisthorchid subfamily, the Metorchiinae, and
is readily differentiated morphologically from
their life cycle features, however, are similar to the other liver flukes (}
The species reported from humans are
M. conjunctus, M. bilis, M. orientalis
Because
their overall prevalence and geographic distributions are limited
compared to that of
Opisthorchis
spp., there is comparatively little information
on their epidemiology, health burden, and control (}
Mas-Coma and Baruges, 1997
For these reasons, species of the
will not be discussed further in this chapter.
Although the metacercariae of the liver flukes species are very similar, they can be
differentiated morphologically and by molecular methods (Figure 4).
1.3 Transmission
1.3.1 Life cycle and routes of transmission
The basic life cycle of the fish-borne liver flukes is shown in Figure 5. Liver flukes utilize as their
first intermediate host freshwater snails belonging to several genera. The egg contains a mature
miracidia that emerges from the egg if it reaches freshwater and is ingested by an appropriate
snail species. In the snail, the miracidial stage then develops to a sporocyst, which then
undergoes asexual multiplication producing rediae, which mature in the snail hepatopancreas
within about 17 days. Each redia, in turn, produces 4-50 cercariae, which emerge from the snail
into the surrounding water. The time between trematode egg ingestion by the snail and the
emergence of the cercariae is influenced by the water temperature; in tropical regions, this
takes about 14-17 days after ingestion of the egg.
An infected snail may
produce and release into the water 500 to 5,000 pleurolophocercus cercariae (Figure 4) per
day, depending on the infection level ( 
The cercariae are phototactic and geotropic
and are able to survive in the water up to 24 hours at temperatures ranging from 12°C to 27°C.
The second intermediate hosts are freshwater fish of the family Cyprinidae; however,
C. sinensis
in fish of other families have been reported (}
movements attract cercariae, which, on contact with the fish, penetrate under the scales, lose
their tails and encyst, mainly in the muscles, subcutaneous tissues, and to a lesser degree in the
In the fish, the metacercaria reaches maturity in about 5-6
weeks, and may remain infective for the definitive host for at least 30 days, probably much
longer although this has not been well characterized
When a metacercaria is
ingested by the definitive mammalian host (e.g., humans), it excysts in the duodenum and
migrates to the common bile duct and then to the biliary ducts within 4-7 hours.
hermaphroditic adult worm reaches sexual maturity and, in four-six weeks, begins producing
eggs that are expelled with the host’s feces. The longevity of adult liver flukes has been
In humans, adult worms may shed 1000 to 4000
eggs per day, depending on the worm burden, which is density-dependent (
Figure 5. Life cycle of human liver flukes. As their common names indicate, the
majority of opisthorchid adults parasitize the liver, bile ducts, and gall bladder of fish
eating mammals including humans. Infected hosts (1) shed the fluke's eggs in their
feces (2) and if the eggs reach water (3), they can be ingested by an appropriate snail
species (4). In the snail, the parasite emerges from the egg and undergoes several
stages of asexual multiplications (4) until emerging from the snail as a swimming
cercariae (5). Fish movements attract cercariae (6), which on contact with the fish...
penetrate various tissues (7), and develop into an encysted metacercariae (8). This
stage is infective to mammals and is transmitted to them when the fish is ingested raw
or improperly prepared. Main reservoir hosts of
Clonorchis sinensis
main reservoir hosts of
Opisthorchis felineus
The risk for human infection is closely related to social and cultural traits that determine food
behaviors, such as a fondness for raw or inadequately prepared fish (i.e., cooked, frozen, or
The consumption of raw or undercooked fish is widely practiced, particularly in
localities near lakes, reservoirs, streams and ponds where fresh fish are readily available.
For example, in China, raw fish is commonly served after dipping briefly in boiling soup.
and immediately eaten, or in hot rice congee. In Thailand, a major source of infection with
is consumption of raw or inadequately cooked, frozen, salted, or smoked fish in a dish
Koi-pla.
In Italy, large
human outbreaks occurred from 2007 to 2011 from the
consumption of marinated tench fillets at restaurants or during social events (}
A strong risk factor for
infection, especially for males, is the consumption of
raw fish at social gatherings where alcoholic drinks are served (}
Studies have
shown that liver fluke metacercariae in fish tissue are moderately tolerant to low levels of heat,
freezing, and pickling (Table 1).
Table 1. Reports on the preservation and treatment parameters necessary to inactivate
liver fluke metacercariae in fish
Preservative  Parameter  Parasite  Process Variable  Time Required for In-activation of Metacercaria

a  Reference  Salting  O. viverrini in fermented fish  13.6%  48 hrs  Kruatrachue et al. 1982
Preservative Parameter Parasite Process Variable Time Required for In-activation of Metacercaria

a Reference

Salting C. sinensis in fish 30.0% (wt based) 8 192 hrs Fan, 1998
<table>
<thead>
<tr>
<th>Preservative</th>
<th>Parameter</th>
<th>Parasite</th>
<th>Process Variable</th>
<th>Time Required for In-activation of Metacercaria</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salting</td>
<td></td>
<td>O. viverrini</td>
<td></td>
<td>20.0% (wt based)</td>
<td>Tesana et al. 1986</td>
</tr>
</tbody>
</table>
Preservative | Parameter | Parasite | Process Variable | Time Required for In-activation of Metacercaria
--- | --- | --- | --- | ---
 | | | Freezing C. sinensis in fish | | -20°C | 72-96 hrs | d | Fan, 1998
<table>
<thead>
<tr>
<th>Preservative</th>
<th>Parameter</th>
<th>Parasite</th>
<th>Process Variable</th>
<th>Time Required for In-activation of Metacercaria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>C. sinensis</td>
<td>WHO, 1979</td>
<td>-10°C, 124 hrs</td>
</tr>
</tbody>
</table>

<p>|             |           | O. viverrini | WHO, 1979 | -10°C, 124 hrs |</p>
<table>
<thead>
<tr>
<th>Preservative Parameter</th>
<th>Parasite</th>
<th>Process Variable</th>
<th>Time Required for Inactivation of Metacercaria</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freezing</td>
<td>O. felinus</td>
<td>-28°C</td>
<td>20 hrs</td>
<td>Fattakhov, 1989</td>
</tr>
</tbody>
</table>
Preservative | Parameter | Parasite | Process Variable | Time Required for In-activation of Metacercaria
--- | --- | --- | --- | ---
| | | | | |
| Reference | | | | 
Freezing | | | | 
O. felinus | in fish | | | 
-35°C | | | | 
8 hrs | | | | 
Fattakhov, 1989 | | | | 
<table>
<thead>
<tr>
<th>Preservative</th>
<th>Parameter</th>
<th>Parasite</th>
<th>Process Variable</th>
<th>Time Required for In-activation of Metacercaria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freezing</td>
<td>-40°C</td>
<td>O. felinus</td>
<td></td>
<td>Fattakhov, 1989</td>
</tr>
</tbody>
</table>
Preservative Parameter
Parasite Process Variable
Time Required for In-activation of Metacercaria
a Reference
Freezing Metacercariae -10°C 120-168 hrs
Lloyd and Soulsby, 1998
Preservative Parameter Parasite Process Variable Time Required for In-activation of Metacercaria

Reference

Freezing O. felinus in fish -18°C 96 hrs Lloyd and Soulsby, 1998
Preservative Parameter
Parasite Process Variable
Time Required for In-activation of Metacercaria

$\text{Heating Metacercariae}$

50°C 5 hrs
Waikagul, 1991
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating Metacercariae</td>
<td>70°C</td>
</tr>
<tr>
<td>Time Required for In-activation of Metacercaria</td>
<td>0.5 hrs</td>
</tr>
<tr>
<td>Reference</td>
<td>Waikagul, 1991</td>
</tr>
<tr>
<td>Parameter</td>
<td>Parasite</td>
</tr>
<tr>
<td>--------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Preservative</td>
<td>O. felineus</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Preservative

Parameter

Parasite

Process Variable

Time Required for In-activation of Metacercaria

a Reference

Irradiation

O. felineus in fish

12.5-25 kGy

e Naz'mov et al., 2001
Preservative Parameter Parasite Process Variable Time Required for In-activation of Metacercaria

a Reference Irradiation

O. viverrini

and C. sinensis

0.15 kGy

Sornmani et al., 1993; Chai et al., 1993
The data presented are the reported treatment conditions that yielded complete inactivation of
Viability was markedly reduced but not completely inhibited;
days had no inactivating effect and 18 days had only marginal inactivating effect;
7 days at
-20°C had no inhibitory effect on 10 rats infected, but 3 days storage at -20°C, followed by
thawing and re-freezing for 4 days had 100% inhibitory effect on 10 infected rats;
above the recommended levels.
There is an age and gender bias in human infections with
O. felineus.
rates of
O. felineus
are generally higher in men than in women, and higher in adults than in
Analysis of clonorchiasis cases have revealed that men 25-55 years
old and women over 45 years are the most highly affected groups in Southern China, Korea, and
North Vietnam
Similar infection patterns are reported for...
O. viverrini
This probably reflects behavioral patterns of
men and alcohol, as mentioned above. The age influence is evident from clinical studies that
indicate that initial infections are acquired at an early age, and repeated exposure results in
the absence of immunity and worm expulsion, in increasing worm burdens and disease
It is important to distinguish human infections acquired in endemic
foci, where people frequently consume raw infected fish, from human infections acquired
sporadically in endemic foci where the consumption of raw fish is infrequent, as in Italy.
1.3.2 Epidemiological role of the intermediate and reservoir hosts
The liver fluke
utilizes, as first intermediate host, snail species including
Melanoides tuberculatus
Parafossilurus
The major snail hosts for
O. viverrini
belong to the genus
Bithynia
The prevalence of larval stages in snails is always quite
low and does not often exceed 1% in endemic foci (
The second intermediate hosts are mainly fish of the family Cyprinidae. Metacercariae of
have been recovered from fish belonging to the genera
Acanthogobius
Carassius
Cirrhinus
Crassiodes, Cultrichthys, Cyprinus
Gnathopogon
Hemibarbus
Hypophthalmichthys
Parabramis
Xenocypris,
Metacercariae of
O. viverrini
were detected in fish of the genera
Carassius
were detected in fish of the genera
Chondrostoma
Cyprinus
Phoxinus
Scardinius
There are reports of shrimp found infected with metacercariae that
morphologically were identified as
C. sinensis
but follow up studies to verify
their identity do not appear to have been conducted. Because shrimp are intermediate hosts for
other trematode species, this report must be provisional.
The large number of fish species reported infected with liver fluke metacerariae (see above)
implies that these parasites have low host specificity (}
therefore important to be aware that in locations where these parasites are found, infections
may occur in several fish species, and the relative infection rates may fluctuate independently,
an important consideration for epidemiological studies. Importantly, wild fish from clean fresh
water sources, such as rivers and reservoirs, are usually preferred for preparing raw fish
All fish-eating mammals, including humans, are potential final hosts of liver flukes. Hosts for
besides humans, include feral and domestic cats and dogs, and pigs
these host species play the crucial role of reservoir host
However,
C. sinensis
has also been reported from sylvatic animals such as martins, civet cats, badgers, monkeys,
weasels, muskrats, foxes and rice rats
The role of sylvatic reservoir hosts is very important in the epidemiology of
which has an even wider spectrum of final hosts; it has been reported from domestic
(e.g., cats, dogs, pigs), synanthropic (e.g., muskrats, rats) and 28 wild animals (e.g., otters,
polecats, polar and red foxes, sable, seals, wild boar, wolverines)
The role of a sylvatic cycle in the epidemiology of
has not been well
studied. A role for wild animal reservoirs is suggested from surveys of fish infections in endemic
areas, which frequently demonstrate that the prevalence of liver fluke metacercariae is often
higher in wild fish from reservoirs, canals, streams and rice fields than in fish from farm ponds.
Cats, dogs and pigs are considered to be the most important reservoir hosts in the domestic
habitat, because of their wide distribution and large populations (}
common assumption that farm households, including humans, dogs, pigs, and cats, play
essential roles in liver fluke epidemiology, the greatest infection risk factor for domestic cats
and dogs is the common practice of allowing such animals to roam and scavenge freely in the
communities (}
Epidemiological studies on the role of cultured and wild-caught fish in liver fluke transmission
have demonstrated that sylvatic hosts, both fish and mammals, can sustain the life cycle and
risk for humans in the absence of a domestic cycle (}
The probable explanation for the higher infection rates of
C. sinenesis
O. viverinni
in wild
caught fish maybe related to both biotic and abiotic factors associated with the different aquatic
habitats of vector snails, especially
Bythinia
Recent research in Thailand and Vietnam on
the ecology and distribution in various aquatic habitats of a major snail host in the genus
revealed a greater abundance in rice fields, streams, and small canals than in lakes.
and in farm ponds (
Further, investigations on the abiotic factors affecting the abundance of
Bithynia siamensis gonioomphalos,
the major snail host for
revealed the
importance of water depth and temperature, level of dissolved oxygen, pH, and salinity
These conditions may not be met in farm ponds that are generally
stagnant, warm, and with low oxygen levels.
1.4 Population and Individual Control Measures
1.4.1 Treatment options
Prevention and control of human liver fluke infections must begin with an effective education.
effort directed at enabling consumers to understand the risks associated with eating raw or
undercooked fish, regardless of source. Currently, the major strategies for community
prevention and control encompasses fecal examination and treatment of individual cases with
praziquantel (25 mg/kg three times daily for 2-3 days), and environmental sanitation by building
and use of household latrines.
Mass chemotherapy
with praziquantel (40 mg in a single dose) is recommended by
sustainability of control by this approach is uncertain (}
infection in humans can be treated with praziquantel (25 mg/kg orally 3×/day for 1–2
days) or albendazole (10 mg/kg/day orally in 2 doses for 7–14 days). The treatment with
praziquantel is, as a rule, effective, whereas treatment with albendazole can fail and the
second treatment, eggs are generally not detected in fecal samples; however, in very few cases,
eggs have been detected after a period from 5 to 6 months up to 2 years despite treatment of
the patients with albendazole ( 
Although the effectiveness of treatment can
be determined based on the search for eggs in stool samples, very few eggs are produced in
cases of unsuccessful treatment; for this reason, ELISA could be used, although the antibody
levels decrease very slowly to the cut-off value (}
Vaccines to prevent liver
fluke infection in humans have not been developed.
1.4.2 Hygiene measures
Emphasis on hygienic measures applicable to households and restaurants may be the most
fruitful approach to control in endemic areas, at least for the immediate future. Treatment of
fish to inactivate the metacercariae by heating to temperatures of 70 °C or above are effective
WHO, 1995
Table 1 lists parameters for inactivation by salting and freezing, pickling, and
irradiation that can be effective (}
use that may inactivate metacercariae, such as microwaving, smoking, fermenting, and
marinating, need further investigation before guidance on their use can be formulated.
metacercariae, for example, can survive in smoked fish causing human infections
nor does marinating does not kill
O. felineus
metacercariae present
Education of food handlers on the risk from fish in endemic areas and on the need to keep
preparation  counters  and  utensils  clean  between  individual  fish  preparations  is  highly
recommended. It should be noted that many home freezers can reach temperatures of -6°C or
but domestic freezers that can operate at a temperature of -18°C or below are more
effective; infected fish need to be frozen in all parts of the products for longer than 24 hours to
ensure that all parasites are inactivated
Investigations in Thailand have demonstrated that low dose irradiation of freshwater fish can
O. viverrini
metacercariae when such fish are prepared in local dishes
made from raw or semi processed fish
Experimental studies should be...
extended in order to evaluate the usefulness of this control measure in food processing.
2.1. Detection Methods
Detection is made most often by microscopy however trained parasitologists are needed to
make the identification. Eggs containing the miracidia of liver flukes can be detected in the
feces by using standard fecal exam methods (e.g., Kato-Katz technic). Fecal deposits picked up
from the ground adjacent to fish ponds, rice paddies, reservoirs and streams, and from latrines
and pig pens, can be collected and tested. This approach has been successful in identifying
reservoir hosts with aquaculture activities and assessing their role in the epidemiology of
Possible ongoing transmission may be detected by examining snails collected from fishponds.
and local waterbodies and examining them for the presence of opithorchid sporocysts and/or
rediae, and for cercariae. This can be done either by crushing the snail and viewing the
remnants under a stereomicroscope or by allowing the snails to shed cercariae directly into
water-filled containers. However, because snails may be infected with other trematodes with
pleurolophocercous type cercaria (Figure 4), especially heterophyid intestinal flukes, a specific
identification of liver fluke cercariae may not be possible.
Examination of local fish can also provide an indication of liver fluke transmission in the area.
Fish tissue can be examined directly by microscope for metacercariae (Figure 4) or, preferably,
after pepsin digestion to free any metacercariae present before examination (}
et al., 2007
Use of molecular methods such as PCR, can make detection more reliable.
Distinguishing liver fluke eggs from the intestinal heterophyid fluke eggs can also be difficult.
Ditrich et al., 1992
and molecular methods applicable to egg identification have also been
2.2 Environmental Contamination with Eggs
There are no data on the occurrence of liver fluke eggs in sewage or various types of polluted
The number of eggs per gram of human feces can be used to roughly calculate potential
egg concentration in sewage. In a study carried out in a focus of clonorchiasis of South Korea,
the mean concentration of eggs was reported to be $2.8 \times 10^\text{?}$
per gram of human feces, with a
range of 12 to 6.6x10
On average, humans excrete approximately
100 grams of feces per person per day and in highly endemic foci of clonorchiasis the
prevalence of infection can reach 70%. Eggs could sediment out into the solids, such as sludge
fields, ponds, streams, canals, or rivers) that contain suitable snail hosts and fish, the liver fluke
2.3 Survival (Persistence) of Eggs in the Environment
Because of a lack of a desiccation-resistant protective coating, trematode eggs and cercariae
information on their survival.
reported that
eggs survived in isotonic solution at 2°C - 4°C for up to 3 months, and at 26 °C for up to
1 month. In fresh night soil, the survival time was 2 days at 25 °C; survival decreased with age.
of the night soil.
observed survival of
O. felineus
for 160 days in river
water held at 0 °C - 5 °C. Field research on egg persistence in soil and water under natural
environmental conditions is needed. Similarly, studies on the survival of eggs in sewage, sludge,
surface water, wastewater and irrigation water are insufficient to draw any conclusions.
3. Reducing Environmental Contamination with Liver Fluke Eggs, Snail Intermediate Hosts, and Cercariae by
3.1 Education and Community-based Actions
Successful control of these parasitic trematodes requires reducing the probability of
transmission. Modifying or breaking the transmission cycle can occur at any stage of the
parasite's life cycle, but both snail and fish infections have proven difficult to control in natural
habitats
Therefore, most control programs aim at reducing and
interrupting transmission at the reservoir host (including humans) level. The approaches to
accomplishing this differ between the three liver fluke species. For examples, wild mammals
play a very important role in maintaining
O. felineus
endemicity ( 
In the case
C. sinensis
uncontrolled free-roaming cats and dogs are important in
these flukes has not been adequately investigated but may be significant. Because of these
non-human hosts, and the importance of wild-caught fish intermediate hosts, the most
important control intervention is the education of consumers in endemic areas. Education of the
relevant communities on the epidemiology and health consequences of liver flukes is a key
component of any control program for all three species (}
Imsomboon, 1997
Health education both at the village and school levels is of major
significance, because infection is often unapparent and CCA only develops after many years
Education should be aimed at explaining the pathology of the
disease and in particular, its association with CCA, and how the parasite is transmitted by
various final and intermediate hosts. It is particularly important to stress the role that eating
raw or partially cooked fish plays in disease transmission
An example of the impact of an education program is the experience in Thailand. Education on
the risks of infection led to the frequency of consumption of raw, or partially cooked or
fermented fish decreasing from 14% in 1990 to 7% in 1994
Jongsuksuntigul and Imsomboon,
In addition to education programs, which are aimed at reducing the risk of infection,
anthelminthic treatment is still required to reduce the output of eggs from infected individuals
into the environment. Because of the lack of acquired protective immunity in human, dog and
cat infections, reinfection of people in endemic areas is likely if they continue to eat raw fish
3.2 Control of Snails
There are many methods employed or proposed to control snails, including chemical control.
molluscicides, physical control
Although these methods...
are applicable to aquaculture ponds, control of snails in marshes, rivers, reservoirs and rice
paddies is impractical and may be environmentally harmful. Many molluscicides, such as copper
have been used but they have toxic effects on fish, water plants, and small organisms, and in
modern aquaculture systems they are either prohibited or discouraged. Biobased molluscicides,
including plant components, may have less toxic effects on humans, aquatic animals, and plants,
and research on them should be encouraged, especially their cost-effectiveness. Studies on
biological control with predatory fish (on snails) such as black carp have recently shown
promise, but this approach is still in the early phase of research and development (}
3.3 Sanitation Technologies
There are no data available on removal of the eggs by wastewater treatment. Their small size
may account for their ability to escape removal from water by standard
filtration systems or sedimentation. Also there are very few recommendations on standard
sanitation measures for the control of human liver flukes, the lack of which may be attributed to
the unique epidemiology of human infections and the ecology of the liver flukes. As discussed in
Section 1.3.2, the liver flukes have a wide range of both domestic and sylvatic reservoir hosts,
and surveys of snails and fish for liver fluke metacercariae consistently reveal a major cycling of
liver flukes through wild, non-cultured fish residing in lakes, reservoirs, streams, rivers,
marshes and rice fields
In contrast,
surveys of fish produced in aquaculture ponds generally reveal low prevalence of
C. sinensis,
even when the human prevalence of
C. sinensis
Further, the human prevalence of liver flukes in
aquaculture systems may be overestimated because of diagnostic confusion between their eggs.
with those of fishborne intestinal flukes (Heterophyidae) (
The major snail vectors of liver flukes (e.g.,
Bythinia
spp.), however, are not
common in fish ponds, preferring instead moving water associated with lakes, reservoirs,
In contrast, the major snail host for the heterophyids,
Melanoidies
is very common
Because most people in
endemic areas consume both wild caught and cultured fish, it is difficult to determine the actual
source of the infected fish. Importantly, wild fish are readily available in local markets and they
are often preferred for raw fish dishes because they are obtained from water that is cleaner and
less polluted than that normally found in farm ponds. The importance of wild caught fish in the
transmission of liver flukes underscores the difficulty of applying standard sanitation
approaches for prevention and control of liver flukes.
3.4 Role for Sanitation Interventions in Aquaculture
When there is evidence that significant transmission from cultured fish is an important source
of human infections, there are interventions that can be implemented in aquaculture systems to
control fish-borne liver and intestinal flukes. These interventions, developed in extensive field
are designed to control fish infections
by eliminating egg contamination of the ponds and reducing the snail populations. They require
a strong program of farmer education and improvements in management practices and pond
infrastructure, as follows:
Before initiating the program's changes to pond infrastructure and management, the
farmers should receive training on the basics of the biology and epidemiology of
fishborne zoonotic trematodes and the health benefits to themselves and their families
for the prescriptive prevention and control interventions.
Household members must be encouraged to avoid eating raw fish and to prevent
consumption of raw or dead fish by farm animals, including dogs, cats and pigs.
Interventions to prevent egg and host fecal contamination of the pond environment
Modification of pond embankments to prevent surface water run-off from entering the
pond by installing a cement barrier at least 10-15 cm above the bank top.
Installation of fencing to exclude reservoir hosts, especially cats and dogs, from the
immediate pond environment.
Prevent discharge into the pond of all waste from latrines and livestock pens.
Interventions to prevent and control snails in the fish pond require that:
Before restocking the ponds with juvenile fish between the harvests, the pond should
be drained and dried completely for at least 5 days. The top 3-5 cm of bottom mud
should be removed to a site not adjacent to the pond.
All vegetation in ponds should be removed, and a liner (plastic or cement) applied to
Aquatic vegetation must be removed at least 3 m from the water intake portal (the
inlet for pond water replenishment) and all incoming water filtered through a 5 mm
mesh screen before entering the pond.
Additional public health actions for endemic communities. Educate households:
on the risk from inadequately prepared fish food;
to avoid contaminating water bodies with human and animal waste to the extent
on the signs and symptoms of liver fluke infection, and to seek medical treatment
when infection is suspected.
High prevalence of Opisthorchis viverrini infection in reservoir hosts in four districts of
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