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The eye fluke *Philophthalmus hegeneri* (Digenea: Philophthalmidae) in Kuwait Bay

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ABSTRACT

The eye fluke *Philophthalmus hegeneri* Penner and Fried, 1963 was reared from cercariae developing in the marine snail *Cerithium scabridum* in Kuwait Bay. Infected snails released megalurous cercariae which readily encysted in characteristically flask-shaped cysts. Adult flukes were recovered from the ocular orbit of experimentally infected domestic ducklings inoculated with excysted metacercariae. The adult and larval stages of the fluke are described and compared with those of the other marine-acquired *Philophthalmus* species. The metacercaria of the Kuwaiti isolate of *P. hegeneri* differs from those of an American isolate from *Batillaria minima* in the Gulf of Mexico in the process of encystment, and metacercarial cyst shape resembles those of *P. larsoni* from a congeneric snail, *C. muscarum*, from Florida, suggesting a close relationship. The present record significantly extends the known geographical range of *P. hegeneri* and implicates a new intermediate host.

Keywords: Digenea; Metacercaria; *Philophthalmus hegeneri*; *Cerithium scabridum*; Kuwait Bay.

INTRODUCTION

Members of the genus *Philophthalmus* Loose, 1899 (Philophthalmidae Travassos, 1918) are widely distributed eye flukes of aquatic birds. The life cycle of *Philophthalmus* has been established through studies on species utilizing freshwater or marine snails as intermediate host (Fisher & West 1958, Penner & Fried 1963, Howell & Bearup 1967, McMillan & Macy 1972, Dronen & Penner 1975, Radev *et al.* 2000). Although more than 36 *Philophthalmus* species have been reported, only *P. andersoni* Dronen & Penner, 1975, *P. burrili* Howell & Bearup, 1967, *P. hegeneri* Penner & Fried, 1963 and *P. larsoni* Penner & Trimble, 1970 are known to use marine snails as intermediate host. Snail intermediate hosts and geographical localities of the marine-acquired *Philophthalmus* species are summarized in Table 1.

In Kuwait Bay, six species of megalurous cercariae have been reported from marine snails (Abdul-Salam & Khedery 1992, Abdul-Salam *et al.* 1994, Abdul-Salam & Sreelatha 1998). In a short communication, Abdul-Salam & Sreelatha

Table 1. *Philophthalmus* species utilizing marine snails as intermediate host.

Philophthalmus	**Snail species**	**Snail family**	**Locality**	**Reference**
P. andersoni	*Cerithium stercusmuscarum* Valenciennes, 1833	Cerithiidae	Gulf of California	Dronen & Penner 1975.
P. burrili	*Velacumantus australis* (Quoy & Gaimard, 1834)	Potamididae	New South Wales	Howell & Bearup 1967.
P. hegeneri	*Batillaria minima* (Gmelin, 1791)	Potamididae	Gulf of Mexico	Penner & Fried 1963, Trimble & Penner 1971.
	Cerithium scabridum Philippi, 1848	Cerithiidae	Kuwait Bay	Present study.
	Clypeomorus bifasciata (Sowerby, 1855)	Cerithiidae	Kuwait Bay	Abdul-Salam & Sreelatha 1995.
P. larsoni	*Cerithium muscarum* Say, 1832	Cerithiidae	Gulf of Mexico	Penner & Trimble 1970, Trimble & Penner 1971.

(1995) reported adult flukes resembling those of *P. hegeneri* from under the eyelids of chicks and ducklings inoculated with metacercariae obtained from megalurous cercariae shed by the snail *Clypeomorus bifasciata* (Sowerby). In the present study, the adult of *P. hegeneri* is reared from megalurous cercariae developing in the marine snail *Cerithium scabridum* Philippi in Kuwait Bay. The larval stages of the fluke are described and compared with those of other marine-acquired *Philophthalmus* species.

MATERIALS AND METHODS

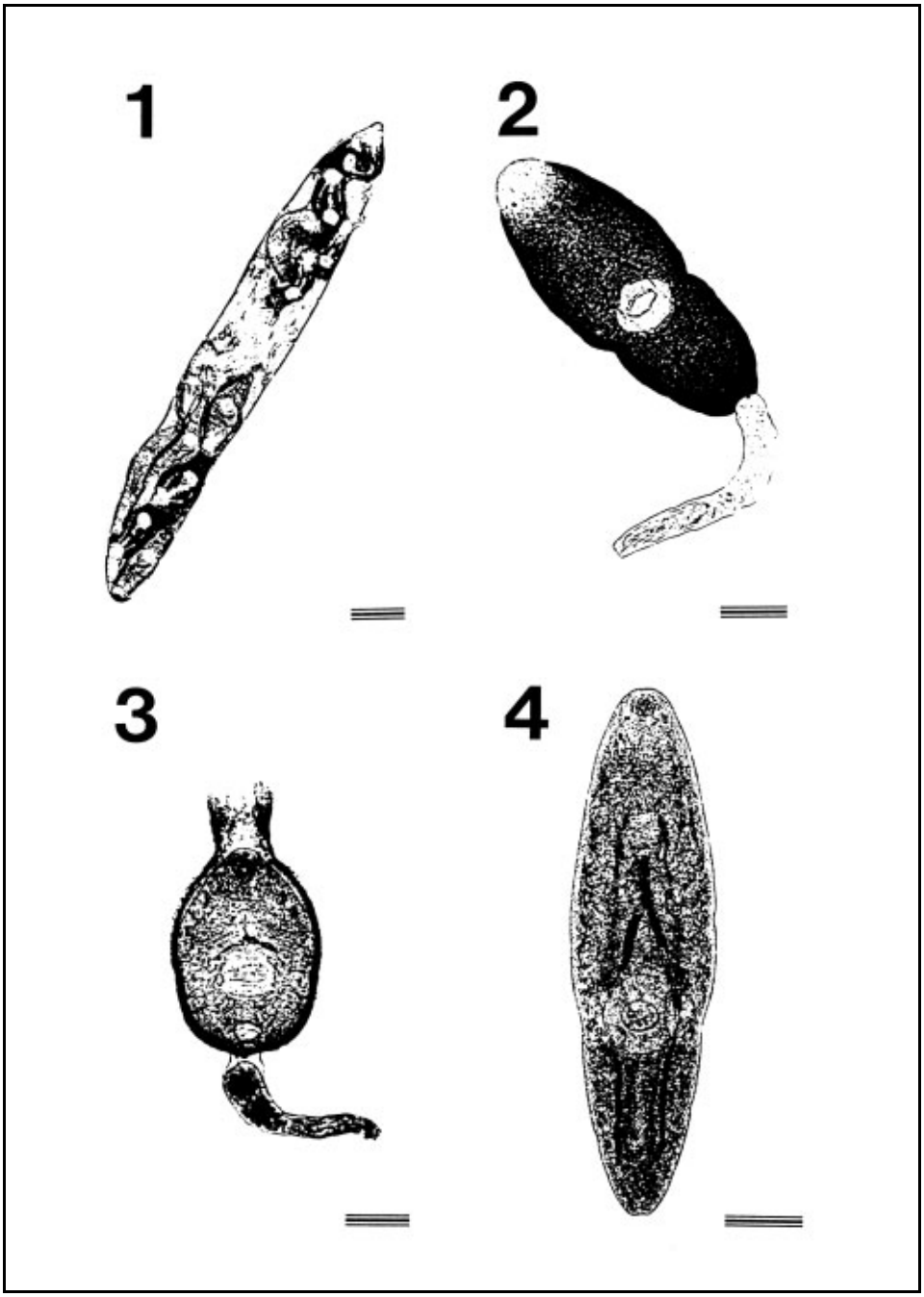
Cerithium scabridum, naturally infected with megalurous (gymnocephalous) cercariae, were collected from the upper eulittoral zone of Shuwaikh shore, southern Kuwait Bay, 2 km west of Kuwait City. Cercarial shedding was induced at room temperature (23-25°C) by placing each snail separately in a small vial filled with filtered sea water, under a diffuse fluorescent light (1400 Lux, 30 μmol m^{-2} s^{-1}) for 72 hr. Infection was detected by the presence of megalurous cercariae adhering to the surface film. Rediae were dissected from the hepatopancreas and gonad of infected snails. Metacercariae excyst within seconds of exposure to 0.85% saline solution warmed to 35-40°C (Alicata & Ching 1960). Two hatchery-raised ducklings were exposed to 15 excysted metacercariae placed around the orbit of each eye. Five weeks post-infection, the eyes and eyelids of the birds were examined for adult flukes. Adult flukes and larval stages were studied alive stained with 0.5% neutral red, and then fixed in hot AFA solution and stained with acetocarmine. Drawings were made with the aid of a *camera lucida* and measurements are in millimetres, given as ranges followed by averages in parentheses. Photomicrographs were taken using Olympus AHBS3 research photomicrographic microscope system.

RESULTS

Redia (Figs 1,7): Mother rediae were not observed in dissected snails. Daughter rediae were found in large numbers in the hepatopancreas and gonad of infected snails.

Description: Based on 15 vital stained mature rediae. Body elongate, 2.05-2.65(2.44) × 0.35-0.45(0.41); 2 lateral appendages (lappets) in posterior half; posterior end tapered. Mouth terminal, surrounded by minute setae; pharynx 0.04-0.06(0.05); gut small containing black granules, approximately one-fifth of body length. Birth pore just posterior to pharynx. Flame-cell formula 2[(2) + (2)] = 8; excretory pore near anterior end of body. Redia contains 1-4 mature cercariae and germinal masses.

Cercaria (Figs 2,8,9): Cercaria with characters of megalurous group as described by Sewell (1922). Upon emergence from the snail, the cercaria alternates periods



Figs.1-4. Photomicrographs of stages of *Philophthalmus hegeneri* from naturally infected *Cerithium scabridum*.
Fig.1. Redia containing developing cercariae (scale-bar = 0.25 mm). **Fig.2.** Ventral view of megalurous cercaria (scale-bar = 0.08 mm). **Fig.3.** Metacercaria within a flask-shaped cyst (scale-bar = 0.07 mm). **Fig.4.** Ventral view of excysted metacercaria (scale-bar = 0.08 mm).

of passive floating and active swimming by simultaneous body and tail undulation, then settles on solid objects and undergoes encystment.

Figs.5-6. Photomicrographs of stages of *Philophthalmus hegeneri* from experimentally infected duckling eyes.
Fig.5. Mature fluke (scale-bar = 0.44 mm).
Fig. 6. Oculate miracidium and empty egg shell (scale-bar = 0.03 mm).

Description: Based on 20 vital stained cercariae. Body elongate, 0.50-0.72(0.59) × 0.19-0.24(0.21), covered with fine spines, encased in thick layer of cystogenous material. Cystogenous glands with granular inclusions fill entire body. Tail 0.28-0.60(0.46) × 0.06-0.07(0.06), smooth, packed with large parenchymal cells; terminal invagination receives ducts of 4 unicellular adhesive glands. Oral sucker oval, 0.06-0.08(0.07) × 0.06-0.09(0.07); mouth subterminal; prepharynx 0.05-0.08(0.07) long; pharynx 0.03-0.05(0.041) × 0.02-0.04(0.03); oesophagus long, bifurcates well anterior to ventral sucker; caeca reach to level of excretory bladder. Ventral sucker 0.08-0.11(0.10) × 0.08-0.10(0.09), just posterior to mid-body. Body and tail with scattered, short setae; cephalic setae mounted on papillae. Cephalic glands 9 pairs between ventral sucker and pharynx; ducts open anterodorsally on margin of oral sucker. Genital

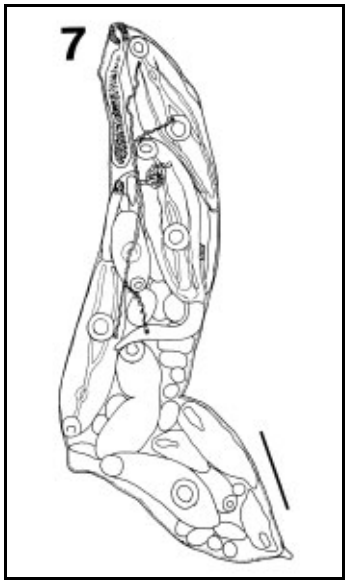


Fig.7. Redia showing developing cercariae and excretory system (scale-bar = 0.25 mm).

primordium forming narrow strip of cells, extending midventrally from excretory bladder to level just posterior to oesophagus. Excretory bladder bulbous, receiving descending collecting ducts separately; ascending collecting ducts divide at level of ventral sucker into anterior and posterior branches; flame cell formula 2 [(3 + 3 + 3) + (2 + 2 + 2)] = 30. Caudal excretory duct short, extending into tail for a short distance, bifurcating and opening laterally.

Metacercaria (Figs 3,4,10): The cercaria encysts readily upon emergence from the snail. The process of encystment starts upon the attachment of the cercaria to the substrate by the oral sucker, ventral sucker and adhesive glands at the tail tip. Stretching and narrowing of the anterior half of the cercaria contribute to the characteristic flask-shaped cyst. Cystogenous material secreted from the entire body forms a wall surrounding the metacercaria and roughly mimicking its shape. The detached tail remains attached to the posterior end of the cyst wall. Metacercariae excyst readily in warm saline; the body of the worm extends and escapes through the neck of the cyst.

Description: Based on 25 live fully-formed metacercarial cysts. Cyst flask-shaped, convex, smooth dorsally; surrounded by flattened edges; cyst 0.23-0.30(0.26) × 0.11-0.13(0.123); neck 0.05-0.09(0.07) × 0.04-0.06(0.05). Excysted metacercaria 0.49-0.61 (0.55) × 0.14-0.18 (0.16).

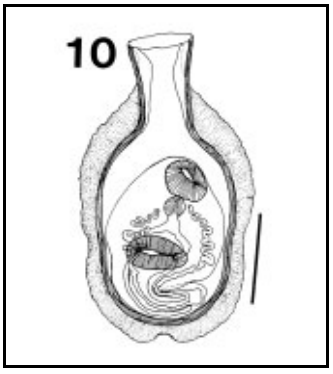


Fig.10. Metacercaria in a flask-shaped cyst (scale-bar = 0.1 mm).

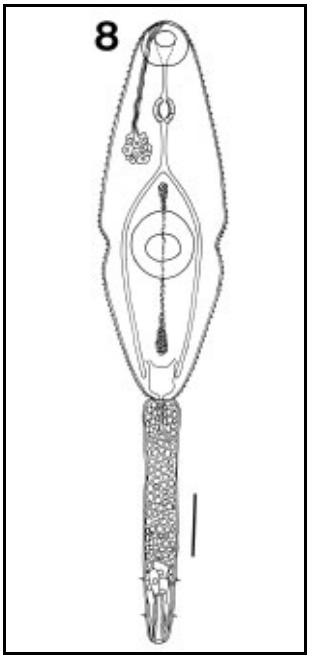


Fig.8. Ventral view of megalurous cercaria (scale-bar = 0.1 mm).

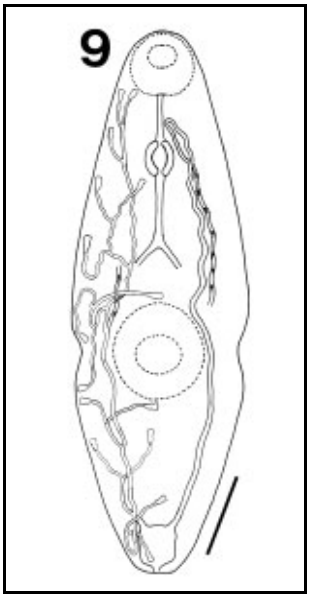


Fig.9. Dorsal view of megalurous cercaria showing excretory system (scale-bar = 0.1 mm).

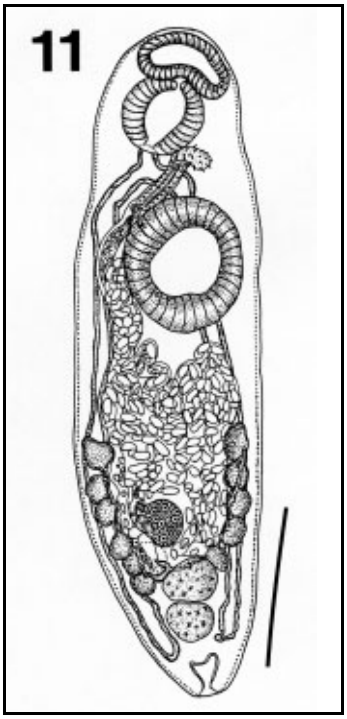


Fig.11. Mature fluke (scale-bar = 0.5 mm).

Adult (Figs 5,11): Five weeks post-infection, 6 and 4 mature flukes were recovered from the nictitating membrane under the eye-lids of 2 ducklings which had been inoculated with 15 excysted metacercariae.

Description: Based on 10 stained and mounted mature specimens. Body elongate with rounded ends, 1.48-2.75(1.8) × 0.45-0.85(0.58), slightly indented at level of ventral sucker. Oral sucker subterminal, transversely oval, 0.17-0.23(0.20) × 0.18-0.30(0.23); prepharynx short; pharynx massive, 0.16-0.28(0.22) × 0.14-0.28(0.21); oesophagus short; intestinal bifurcation about midway between oral sucker and ventral sucker; caeca extending to level of posterior testis. Testes 2, tandem, entire, in posterior end of body. Ventral sucker large, 0.27-0.45(0.34) × 0.28-0.45(0.35), in anterior third of body. Anterior testis, 0.09-0.30(0.15) × 0.1-0.41(0.19); posterior testis 0.09-0.33(0.16) × 0.1-0.41(0.18). Vasa efferentia unite before reaching cirrus sac, form vas deferens. Cirrus spined; cirrus sac slender, elongate, 0.20-0.33(0.26), just anterior to ventral sucker; seminal vesicle, lateral to ventral sucker. Genital pore median, anterior to ventral sucker, at level of intestinal bifurcation. Ovary submedian, anterior to anterior testis, 0.09-0.14 (0.12) × 0.07-0.15(0.11); oviduct short, narrow, joined by Laurer's canal and duct from vitelline reservoir. Vitellarium follicular, in 2 lateral rows of 5 and 6 round follicles, 0.05-0.09(0.07) in diameter. Mehlis' gland posterior to ovary. Uterine coils occupy entire region between anterior testis and ventral sucker. Metraterm, muscular, begins posterior to ventral sucker. Excretory bladder triangular, at posterior extremity.

Egg (Figs 6,12): Non-operculate, 0.05-0.08(0.06) × 0.02-0.03(0.027), contains fully-developed miracidium with daughter sporocyst inside.

Miracidium (Figs 6,13): Eggs hatch immediately when placed in contact with seawater, releasing ciliated miracidia.

Description: Based on 15 vitally stained specimens. Miracidium oval. Ciliated epithelial cells arranged in 4 epidermal plates. Apical gland with large granules. Eyespots in form of pair of dark-brown

pigmented bodies, between first and second rows of epidermal plates. Miracidium contains single daughter sporocyst.

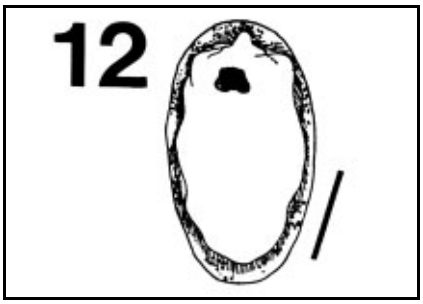


Fig.12. Fully embryonated egg (scale-bar = 0.05 mm).

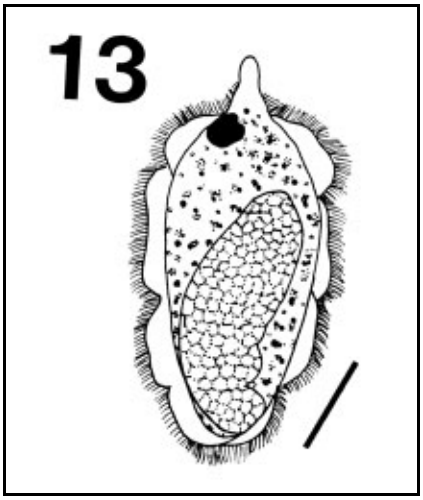


Fig. 13. Miracidium containing sporocyst (scale-bar = 0.05 mm).

Taxonomic summary

Intermediate host: *Cerithium scabridum* Philippi, 1848 (Prosobranchia, Cerithiidae).

Locality: Intertidal zone of Shuwaikh shore, Kuwait Bay (29°21.57′N, 47°57.08′E).

Experimental definitive host: *Anas platyrhynchos* (Anatidae).

Specimens: Voucher specimens of the adult and larval stages of *Philophthalmus hegeneri* form Kuwait Bay are deposited in the Natural History Museum, London No. 1994.4.12.1-4.

DISCUSSION

The adult fluke described in the present study is identical with the eye fluke described and identified by Penner & Fried (1963) as *Philophthalmus hegeneri*. The occurrence of *P. hegeneri* in the prosobranch snail *Cerithium scabridum* in Kuwait Bay constitutes a new intermediate host and geographical record, since the original description of the adult fluke and the larval stages were from the marine snail *Batillaria minima* (Gmelin) in the Gulf of Mexico, Florida (Penner & Fried 1963). The life cycle of *P. hegeneri* is in accordance with that of the other species of the genus. The adult fluke inhabits the nictitating membrane of the avian host. Eggs hatch immediately when placed in contact with seawater, releasing ciliated miracidia with eyespots and containing a daughter-sporocyst. Miracidia seek and penetrate compatible marine prosobranch snails. Within the hepatopancreas and gonad of the snail host, redia gives rise to cercariae belonging to the megalurous group. Cercariae escape from the snail and encyst in characteristically flask-shaped cysts on solid objects. Upon ingestion by birds, the metacercariae excyst and migrate from the mouth to the inner side of the

nictitating membranes of the eye orbits via the nasal cavities and nasolachrymal ducts. Adult *P. hegeneri* is related to the lucipetus group of the genus in having a follicular rather than a tubular vitellarium (Nollen & Kanev 1995). The group also includes *P. andersoni* Dronen & Penner, 1975, *P. lachrymosus* Braun, 1902, *P. larsoni* Penner & Trimble, 1970, *P. lucipetus* (Rudolphi, 1819) and *P. skrjabini* A. Efimov, 1937. However, *P. hegeneri* is distinguished by the location of the seminal vesicle anterior to the posterior border of the ventral sucker and the transverse ratio of the suckers is 1: 2, while the sucker-ratio of the other species is 1: 8. The present description of the adult flukes concurs with Penner & Fried's (1963) description, and the apparent morphological variations in the dimensions of the body and reproductive organs (Table 2) are probably attributed to intraspecific variation, the experimental protocol or experimental host used. Ching (1961) showed variations, in the morphology of the reproductive organs of *P. gralli* Mathis & Léger, 1910 adult to be due to age and the type of the experimental avian host.

Several studies have been focused on the biology of the larval stages of *P. hegeneri* from naturally infected *B. minima* in Florida (Trimble & Penner 1971, Fried & Grigo 1975, 1976, Haas & Fried 1974). The general morphology of the larval stages of *P. hegeneri* from *C. scabridum* in Kuwait is similar to those of the other marine-acquired species, this is despite size variations in the larval stages presented in Table 3. Trimble & Penner (1971) reported measurements of larval stages of *P. hegeneri* that are considerably larger than those reported in the present study. In contrast, Fried & Grigo (1976) reported substantially smaller measurements, comparable to the Kuwaiti isolate, and attributed the discrepancies in the measurements of the American isolate to different fixation procedures. The rediae of *P. hegeneri* isolates from Kuwait and Florida are characterized by a short gut confined to the anterior fifth of body, while in *P. andersoni, P. burrili* and *P. larsoni* the gut is significantly longer, reaching close to the posterior end of the body. In contrast to the earlier descriptions of the cercaria of *P. hegeneri* (Trimble & Penner 1971, Fried & Grigo 1976), the present study provides a complete description of the arrangement of the excretory system, elucidating details of the anterior and posterior branches of the ascending collecting ducts, which are often obscured by a thick cystogenous material. The flame cell formula and arrangement of the collecting ducts in *P. hegeneri* is similar to that of freshwater-acquired species of *Philophthalmus* (Ching 1961, West 1961).

The most striking difference between metacercariae of the Kuwaiti and American isolates of *P. hegeneri* is in the process of encystment and morphology of the metacercarial cyst. The metacercaria of the Kuwaiti isolate is

Table 2. Comparison between adult *Philophthalmus* species from avian hosts experimentally infected with metacercariae from marine snails.

Character	*P. andersoni*	*P. burrili*	*P. hegeneri* (Florida)	*P. hegeneri* (Kuwait)	*P. larsoni*
Body	3.52-5.12 × 0.91-1.16 (4.26 × 1.05)	2.8-3.7 × 0.70-1.4	1.86-5.46 × 0.81-1.80	1.48-2.75 × 0.45-0.85 (1.80 × 0.58)	4.12-6.04 × 0.93-1.67 (4.91 × 1.66)
Oral sucker	0.20-0.21 × 0.28-0.35 (0.21 × 0.30)	0.21-0.27 × 0.30-0.37	0.25-0.49 × 0.36-0.55 (0.46)	0.17-0.23 × 0.18-0.30 (0.20 × 0.23)	0.25-0.56 × 0.30-0.70 (0.32 × 0.41)
Pharynx	0.23-0.30 × 0.25-0.31 (0.27 × 0.30)	0.25-0.30 × 0.24-0.28	0.23-0.36 × 0.20-0.36	0.16-0.28 × 0.14-0.28 (0.22 × 0.21)	0.26-0.51 × 0.26-0.66 (0.34 × 0.35)
Oesophagus	0.13-0.19 (0.17)	0.15-0.25	0.13-0.41	ND	0.24-0.50 (0.37)
Ventral sucker	0.45-0.69 × 0.47-0.65 (0.6 × 0.54)	0.40-0.55 × 0.40-0.55	0.65-0.93 × 0.64-1.03 (0.84)	0.27-0.45 × 0.28-0.45 (0.34 × 0.35)	0.43-0.75 × 0.53-0.71 (0.59 × 0.61)
Anterior testis	0.28-0.43 × 0.41-0.60 (0.39 × 0.56)	0.30-0.40 × 0.35-0.55	0.22-0.54 × 0.25-0.72 (0.49)	0.09-0.30 × 0.10-0.41 (0.15 × 0.19)	0.32-0.66 × 0.20-0.84 (0.44 × 0.46)
Posterior testis	0.26-0.34 × 0.36-0.52 (0.32 × 0.50)	0.25-0.50 × 0.40-0.55	0.23-0.59 × 0.23-0.79 (0.51)	0.09-0.33 × 0.10-0.41 (0.16 × 0.18)	0.29-0.67 × 0.26-0.66 (0.48 × 0.48)
Ovary	0.21-0.27 × 0.21-0.26 (0.23 × 0.24)	0.17-0.25 × 0.17-0.25	0.15-0.32 × 0.18-0.34 (0.26)	0.09-0.14 × 0.07-0.15 (0.12 × 0.11)	0.16-0.37 × 0.20-0.38 (0.24 × 0.28)
Egg	0.096-0.11	0.09-0.095 × 0.05	0.05-0.08 × 0.02-0.04	0.05-0.08 × 0.02-0.03 (0.06 × 0.027)	0.06-0.07 × 0.025-0.031 (0.06 × 0.028)
Sucker-ratio	1 : 1.8	1 : 1.4	1 : 1.8	1 : 1.5	1 : 1.5
Ovary to testis ratio	1 : 2.3	1 : 2.1	1 : 1.9	1 : 1.7	1: 1.6

Measurements are in millimetres; length × width ranges followed by averages in parentheses.
ND = Not determined.

Table 3. Comparisons between larval stages of *Philophthalmus* species utilizing marine snails as intermediate host.

Larval stage	*P. andersoni*	*P. burrili*	*P. hegeneri* (Florida)	*P. hegeneri* (Kuwait)	*P. larsoni*
Redia					
Body length	1.79-1.95 (1.84)	1.5	1.44	2.05-2.65 (2.44)	0.86
Body width	0.31-0.35 (0.33)	0.35	0.09	0.35-0.45 (0.41)	0.19
Pharynx	ND	0.1	0.06	0.04-0.06 (0.05)	0.06
Cercaria					
Body length	0.50-0.65 (0.54)	0.60	0.89	0.50-0.72 (0.59)	0.44-0.75 (0.61)
Body width	0.44-0.24 (0.17)	(0.175)	0.24	0.19-0.24 (0.21)	0.12-0.22 (0.19)
Oral sucker	0.52-0.80 (0.68)	0.05	0.11 × 0.10	0.06-0.08 × 0.06-0.09 (0.7 × 0.07)	0.08 × 0.07
Prepharynx	ND	0.095	0.07	0.05-0.08 (0.07)	0.06
Pharynx	0.036-0.044 (0.042)	0.04	0.06 × 0.03	0.03-0.05 × 0.02-0.04 (0.041 × 0.036)	ND
Ventral sucker	0.60-0.80 (0.70)	0.8	0.12 × 0.13	0.08-0.11 × 0.08-0.10 (0.10 × 0.09)	0.08 × 0.09
Tail	0.30-0.45 (0.36)-	0.30	0.29-0.61 (0.41)	0.28-0.60 (0.46)	ND
Metacercarial cyst					
Cyst	0.32-0.38 × 0.16-0.19 (0.37 × 0.18)	0.3-0.5 × 0.175-0.234	0.44-0.57 (0.53) × 0.26	0.23-0.30 × 0.11-0.13 (0.26 × 0.123)	0.46-0.38 × 0.19-0.20 (0.43 × 0.20)
Neck	0.098-0.126 × 0.054-0.068 (0.114 × 0.062)	ND	(Short) × 0.09	0.05-0.09 × 0.04-0.06 (0.07 × 0.05)	0.12 × 0.07

Measurements are in millimetres; length × width ranges followed by averages in parentheses.
ND = Not determined.

distinguished from the American isolate by a pronounced neck formed by the anterior half of the cercaria. However, this metacercariae and that of *P. larsoni* from *Cerithium muscarum* in the Gulf of Mexico (Trimble & Penner 1971) exhibit a similar cyst shape and process of formation. The metacercariae of both species are characterized by a flask-shaped cyst with a pronounced neck, and the detached tail of the cercaria is found attached to the posterior end of the metacercarial cyst wall. This interspecific similarity in the formation and morphology of metacercarial cysts of *Philophthalmus* species from the two congeneric snail hosts, suggests a close evolutionary relationship. Studies on interspecific variations between adults of a species of *Philophthalmus* by Swarnakumari & Madhavi (1992) raised a serious question regarding the validity of the more than 40 described species. Histochemical studies on the Hawaiian (Thakur & Chang 1968) and Texan (Abu Bakar & Nollen 1986) isolates of *P. gralli* have shown constant morphological differences in the type and location of the cystogenous glands of the cercariae. The possibility of interspecific variation between *Philophthalmus* species is further supported by their reproductive strategy of cross-insemination. Howell & Bearup (1967) found that cross-fertilization is necessary for egg embryonation in *P. burrili* and Nollen *et al.* (1985) proved that the Hawaiian and Texan strains of *P. gralli* are able to cross-inseminate. Reported interspecific variations between *Philophthalmus* species warrant further investigations utilizing molecular and biochemical techniques.

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المثقوبة المتطفلة على العين فلفثالمس هجنيري في جون الكويت

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خلاصة

تم استزراع الطور اليافع للمثقوبة (trematode) المتطفلة على العين، فلفثالمس هجنيري بنر و فرد، 1963 من مذنبات (cercariae) متطفلة علي القوقع سريثيوم سكبريدم في جون الكويت. القواقع المصابة تطلق مذنبات مجلوريسية (megalurous) سرعان ما تتحول الي متاسركاريا (metacercaria) محاطة بأكياس قارورية الشكل. تم عزل الطور اليافع للمثقوبة من تحت جفون بطيطات تم حقنها في المختبر بمتاسركاريا بعد بزوقها من الأكياس. تم وصف الطور اليافع والأطوار اليرقية للمثقوبة و مقارنتها بالأنواع الأخرى من فلفثالمس التي تتطفل على قواقع بحرية. تختلف متاسركاريا فلفثالمس هجنيري في الكويت عن تلك التي تتطفل على القوقع بتليريا منما في خليج المكسيك في طريقة التكيس و شكل الكيس. بيد أن هناك تشابهه كبير بين متاسركاريا فلفثالمس هجنيري في الكويت و فلفثالمس لارسونى من القوقع سريثيوم مسكارم في فلوريدا، مما يشير إلى علاقة تطورية بين هذين النوعين. اكتشاف فلفثالمس هجنيري في جون الكويت يعتبر سجلاً جديداً للانتشار الجغرافي لهذه المثقوبة و القوقع سريثيوم سكبريدم يمثل عائلاً وسيطاً جديداً.