AUSTROPOTAMOBIUS TORRENTIUM (SCHRANK, 1803) IN THE AGGITIS CAVE (NORTHERN GREECE). IS IT A CAVE-DWELLING SPECIES?

E.T. KOUTRAKIS (1), Y. MACHINO (2), A. KALLIANIOTIS (1), D.M. HOLDICH (3)

(1) Fisheries Research Institute of Kavala, National Agricultural Research Foundation, GR-64007 Nea Peramos, Kavala, Greece.
E-Mail: koutrman@otenet.gr

(2) Higashi-Monzen-cho 520-4, Sakyo-ku, Kyoto 606-8345, Japan.
E-Mail: yoichi.machino@fnac.net

(3) EMEC Ecology, The Old Ragged School, Nottingham, NG1 1EA, England.
E-Mail: david.holdich@ntlworld.com

Reçu le 4 novembre 2004 *Received November 4, 2004*
Accepté le 23 décembre 2004 *Accepted December 23, 2004*

ABSTRACT

Although the stone crayfish, *Austropotamobius torrentium* (Schrank, 1803), is widespread in central and southeastern Europe, including Greece, it has not been recorded living deep inside caves before. Recently, however, it has been recorded from a variety of depths inside the Aggitis Cave in northern Greece. The crayfish have been found in the out flowing River Aggitis, in the entrance to the cave, as well as at 2,100 m and 7,100 m from the entrance. The crayfish found were pigmented in general, although those from the deeper parts had characteristically bluish pereopods. The finding of crayfish so deep inside a cave system is unusual, and is probably the deepest record so far in Europe and North America. The origin of the deep-dwelling crayfish is unknown. Although they occur above the cave system, it is unlikely that they could have entered the system from there in recent times due to a build up of sediment, but they may have become trapped in the cave prior to this happening. Alternatively, they may have moved upstream into the cave system over time. It is hoped to determine whether they complete the whole of their life history in the cave system and what they are feeding on.

Key-words: crayfish, *Austropotamobius torrentium*, cave dwelling species, Aggitis Cave, Greece.

AUSTROPOTAMOBIUS TORRENTIUM (SCHRANK, 1803) DANS LA GROTTE AGGITIS (GRÈCE SEPTENTRIONALE). EST-CE UNE ESPÈCE TROGLODYTE ?

RÉSUMÉ

Bien que l'écrevisse de torrent, *Austropotamobius torrentium* (Schrank, 1803), soit largement répandue en Europe centrale ainsi qu'au sud-est avec la Grèce, jusqu'à présent, elle n'a jamais été signalée en profondeur en ce qui concerne une grotte. Récemment, elle a été découverte à différentes profondeurs de la grotte d'Aggitis en Grèce septentrionnale. Les écrevisses ont été trouvées dans la rivière Aggitis (l'exutoire de la grotte), à l'entrée de la grotte et également à 2 100 m et à 7 100 m à l'intérieur de

Article available at http://www.kmae-journal.org or http://dx.doi.org/10.1051/kmae:2005012

la grotte. Ces écrevisses étaient en général pigmentées, bien que celles des zones plus profondes soient caractérisées par des péréopodes bleuâtres. La présence des écrevisses dans des zones si profondes d'un système de cavernes est inhabituelle et, de plus, elles sont situées à la plus grande profondeur signalée jusqu'alors en Europe ou en Amérique du Nord. L'origine des écrevisses vivant dans les zones profondes est inconnue. Bien qu'elles vivent sur la terre de surface au-dessus de la grotte, c'est peu probable qu'en raison de l'accumulation des sédiments à l'amont de la grotte, elles ont pu y pénétrer depuis l'amont dans le passé récent. Mais elles auraient pu être piégées dans la grotte avant que l'accumulation ait eu lieu. Une seconde explication serait la possibilité pour les écrevisses d'avoir migré depuis l'aval, c'est-à-dire l'exutoire de la grotte, au cours du temps. Dans le futur, il faudrait déterminer si les écrevisses passent leur vie entière dans la grotte et ce dont elles s'alimentent.

Mots-clés : Écrevisses, *Austropotamobius torrentium*, espèce troglodyte, grotte d'Aggitis, Grèce.

INTRODUCTION

The stone crayfish, *Austropotamobius torrentium* (Schrank, 1803), is mainly found in central and southeastern Europe, its most southerly limits being in Greece (KINZELBACH, 1986; HOLDICH, 2002; TRONTELJ, MACHINO and SKET, 2004; MACHINO and HOLDICH, *in press*). It often occupies upland brooks and rivers in forested areas with a structural richness of the banks, and usually prefers stony substrates (LAURENT, 1988; KAPPUS, PEISSNE and RAWER-JOST, 1999). However, it can also be found in rivers flowing through agricultural land, sometimes in conjunction with the noble crayfish, *Astacus astacus* (Linnaeus, 1758), *e.g*. River Kammel in Bavaria (D. M. HOLDICH, unpub. data). According to the literature, it has seldom been recorded from the hypogean environment up to now, and this has been confirmed by Dr B. SKET (pers. com., October 2004). The information by BOTT (1972) on the occurrence of *A. torrentium* from the Tkalca Jama Cave at Rakov Skocian near Postojna (Slovenia) belongs to one of the rarest cases. But BOTT (1972) did not detail the distribution within and around the cave. The recent finding of *A. torrentium* deep inside a cave in northern Greece described below is therefore of great interest.

The Greek cave fauna was studied by BERON (1986) but no crayfish were found in any of the caves. PARAGAMIAN (1994) in an environmental study aimed at creating a part of the Aggitis Cave to be opened to visitors, did a survey only in the first 480 m (only 2,650 m were known at that time). He mentions the presence of *A. torrentium* as an occasional visitor of the cave. But its occurrence is not surprising there in fact, as one of us (Y.M.) found the species during the crayfish survey of 1996 in the Aggitis River (downstream of the Aggitis Cave) on one hand and in the Kato Nevrokopio drainage (upstream of the cave) on the other hand.

The Aggitis Cave

The Aggitis Cave (or Maaras) (Figure 1) is found in North Greece, 1 km north of the Aggitis village (Municipality of Prosotsani), 25 km west of the city of Drama. The entrance of the cave is at 41°13'N and 23°53'E at an altitude of 127 m. From the entrance of the cave the River Aggitis flows out. It is a tributary of the Strymon River that flows into the Aegean Sea. The cave is found in the south of Falakro Mountain and it is one of the most important in Greece, since it is the only one that is run through by a river. The part of the cave that has been explored to date reaches to 7,800 m from the entrance and contains 10,150 m of galleries. The cave is connected with the swallow-holes of Ohiron on the other side of the mountain, at 535 m altitude (408 m hypsometrical difference) that drain the valley of Kato Nevrokopio (DIMADI, XEIDAKIS and MARINOS, 1993). The distance from the swallow holes to the entrance of the cave is estimated to be around 9,000 m

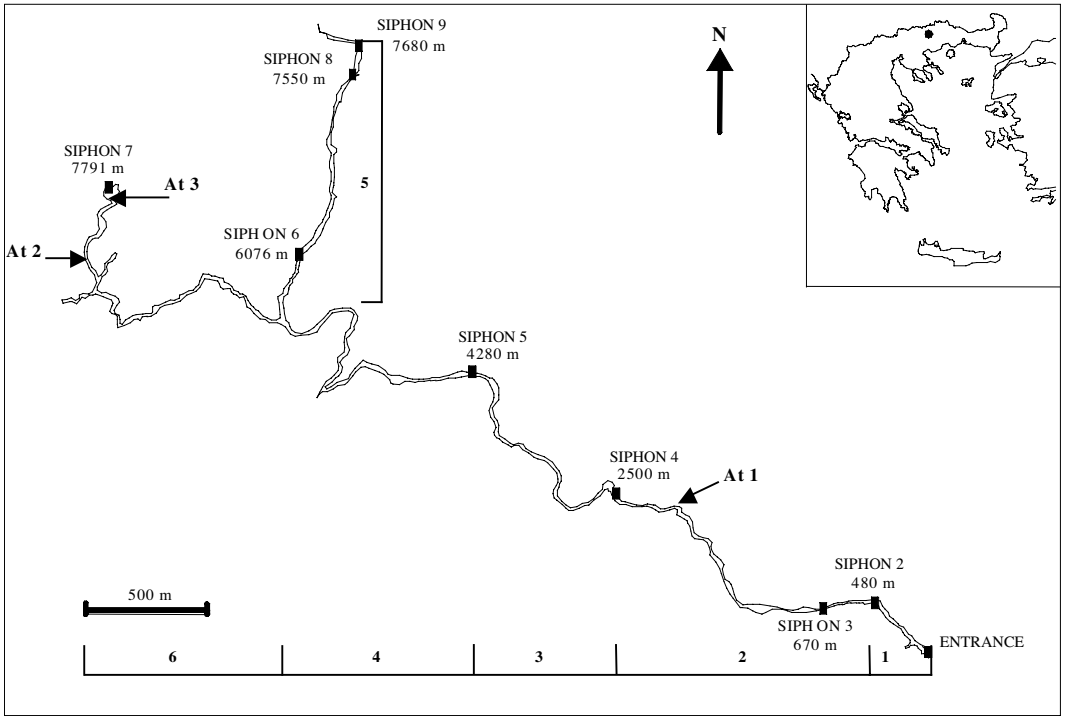

Figure 1

Map of the Aggitis Cave, North Greece (created from REILE, 2000). The different parts of the cave separated by the siphons are noted with numbers in the bottom (siphon 1 is not noted because it is by passed by an artificial tunnel now) and sites where specimens of *A. torrentium* (At) were caught are noted.

Figure 1

Carte de la grotte Aggitis, Grèce orientale (d'après REILE, 2000). Les différentes parties de la grotte, séparées par les siphons, sont indiquées par des numéros (le siphon 1 n'est pas mentionné car il est maintenant atteint par un tunnel artificiel) et les sites où les spécimens d'*A. torrentium* ont été capturés sont indiqués par (At).

(PARAGAMIAN, 1994). The cave is the biggest karstic tunnel in Greece; more than half of its cross-section, in some cases more than 10 m, is covered by sediments, mainly mud and sand (XEIDAKIS, 1996).

The cave is divided in six parts that are separated by siphons (Figure 1). The first part is open to visitors and it was created after a thorough study (XEIDAKIS, 1996). It is 480 m long, 5 to 26 m width and has maximum height of 8.5 m; near the entrance a hall of 35 m length, 50 m width and 15 m height is situated ("Hall of Mylos"). Siphon 1 is not mentioned in the map, because it has been by-passed during the works for creating a part of the cave open to visitors. From siphon 2 (10 m long) to siphon 4 (15 m long) there are 2,000 m of galleries, 10-20 m width and 10-15 m height. Another hall, the "Acropolis Hall" (named by the French speleological group that has been visiting the cave since 1978), one of the biggest subterranean halls in Greece with length 90 m, width 60 m and height 40 m, is found in this part, some 1,150 m from the entrance of the cave. Siphon 4 to the third part is only 45 cm in height and after 1,800 m siphon 5 (similar to 4), that can be passed through only by diving (as all the following siphons), is reached. The fourth part ends at a crossing at 5,800 m. At that point the cave is divided with one part directed to the north (the fifth

part), which has more water at a temperature of 16.5°C and another part directed north-west (the sixth part), which has a mean temperature of 12°C. The fifth part is 1,800 m long till siphon 8, which is 70 m long and 6.5 m deep, and another 150 m till siphon 9, which is at least 75 m long and 31 m deep. It has not been possible to go through this part yet. The sixth part after 2,000 m ends at a siphon (n° 7) more than 50 m long and 25 m deep that also was not possible to go through yet (REILE, 2000; THEODOSIADIS, TZAVELAS and NIKOLAIDIS, 2003; SPELEO, 2003).

METHODS AND RESULTS

The aquatic macrofauna of the Aggitis Cave (Maaras) of Drama was recorded in four surveys in autumn 2002. Two traps of 4 mm mesh size knot-to-knot (Figure 2) were manufactured by FRI technicians and were placed with bait (salted fish) at 1,150 m and at 2,100 m from the entry of the cave (second part). Also in the two first sections electrofishing and a bag seine were used. During the first preliminary survey a depth of 2,500 m was reached and the research methods were evaluated. The second survey also reached to 2,500 m and all the fishing equipment was used. During this survey one male *A. torrentium* was found in the trap at the 2,100 m depth (Figure 1, At 1). The crayfish was pigmented but the pereopods had a bluish colour (Figure 3). During this survey another five specimens of *A. torrentium* were caught in the first part of the cave but they didn't have the characteristic bluish colour of the specimens found deeper in the cave (cephalothorax length = 28.05, 31.23, 33.70, 34.67 and 41.11 mm).

The third and fourth surveys were organised with the help of speleo-divers up to the depth of the 7,800 m, where only a small dip net was used. During the third survey another male *A. torrentium* was caught at 7,100 m with the same bluish colour (Figure 1, At 2). The morphological characteristics of the two specimens caught at 2,100 and 7,100 m are shown in Table I. During the fourth survey the diver who was trying to pass through the siphon 7 at the end of the sixth part (7,800 m), at a distance of 45 m from the beginning of the siphon and at a depth of 25 m, estimated that 15-20 specimens of crayfish were present (Figure 1, At 3). The diver could not pass the siphon because he found a narrow part where he could not go through.

During the sampling time the water flow in the entrance of the cave was 1.23 $m^3 s^{-1}$ (SD = 0.04). Different water samples were also taken in different parts of the cave. The

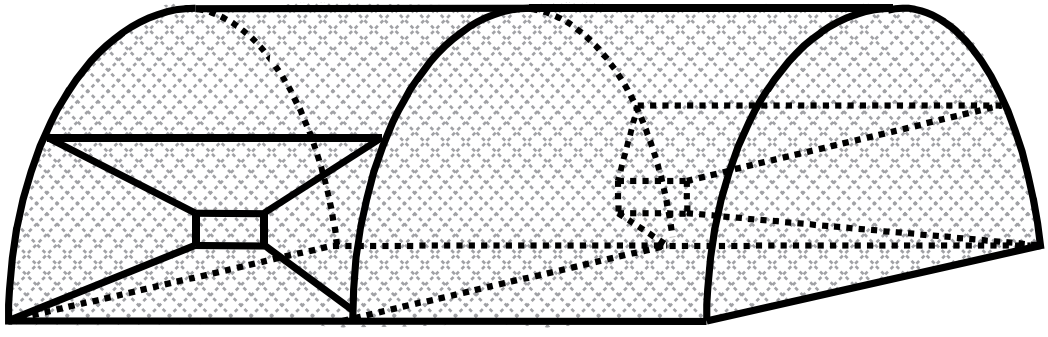

Figure 2
Design of the trap (40 × 30 × 22 cm) used in the Aggitis Cave for capturing crayfish.

Figure 2
Nasse (40 × 30 × 22 cm) utilisée dans la grotte d'Aggitis pour attraper les écrevisses.

Figure 3
Photo of *A. torrentium* from the Aggitis Cave caught at 7,100 m depth from the entrance of the cave during autumn 2002.

Figure 3
Photo d'un spécimen de *A. torrentium* de la grotte d'Aggitis, capturé à 7 100 m de profondeur depuis l'entrée de la grotte en automne 2002.

results of the water analysis are shown in Table II. The sample taken at 5,100 m has high $N\text{-}NH_4$. This is believed to be due to the water coming from the fifth part that also has higher temperature and maybe this is the reason that no crayfish were found there.

Although *A. torrentium* lives in the Kato Nevrokopio drainage, a rough search, on July 3rd, 2003, around the swallow holes, using electrofishing, did not reveal any crayfish.

DISCUSSION

The authors don't have enough data to explain the origin of *A. torrentium* in the deep parts of the Aggitis Cave. Whether they have come from the upstream Kato Nevrokopio drainage or have moved up from the downstream Aggitis River is not known. Also, whether they are able to carry out the whole of their life history inside the cave or are merely erratic in the cave remains open to question. However, it seems that the population today (and at least for the past 20 years) is isolated in the deep part of the cave. After discussions that one of us (E.T.K.) had with geologists and speleo divers who know the cave, we can say that today it would be very difficult for the animals to pass either from the swallow holes, because there are probably sediments after the swallow holes or by moving upstream from River Aggitis, because in the cave there are steep barriers (also mentioned by SPELEO, 2003) that make it very difficult for animals to go through (speleologists climbed over the steep barriers to go to the other side). So, probably these animals are isolated in the cave today, thus they pass their life in the cave. However, 50 years ago, when speleologists first visited the cave and the swallow holes (PETROCHEILOS, 1952), they described that the big swallow hole was not covered by sediments and they could enter into a cave that led

Table I

Sex and morphological characteristics of the two specimens of *A. torrentium* caught deep in the Aggitis Cave (one in 2,100 and one in 7,100 m) during autumn 2002.

Tableau I

Sexe et caractéristiques morphologiques des deux spécimens d'*A. torrentium* attrapés dans la zone profonde de la grotte Aggitis (l'un à 2 100 m et l'autre à 7 100 m) en automne 2002.

	7,100 m	2,100 m
Sex	Male	Male
Cephalothorax (mm)	30.18	35.37
Rostrum (mm)	5.38	6.96
Acumen (mm)	1.82	2.18
Tail (without telson) (mm)	28.76	34.05
Telson (mm)	6.31	9.2
Eye diameter (mm)	1.9	2.2
Spines behind the cervical groove	no spines 3 tubercles each side	no spines 3-4 tubercles each side
Spines on the merus of the 3rd maxilliped	1 spine	1 spine
Rostral median crista	absent	absent
"Talon" on the pleopod 2	present	present

Table II

Suspended matter (spm) and nutrients (mg/l) from water samples taken at different depths of the Aggitis Cave during autumn 2002. The parts of the cave, as shown in Figure 1, where samples are taken are also noted. The crayfish were caught at 2,100 m (2nd part) and 7,100 m (6th part) deep.

Tableau II

Matières en suspension (spm) et nutriments (mg/l) dans les échantillons d'eau prélevés à différentes profondeurs en automne 2002. Les parties ou sections de la grotte, où ont été prélevés les échantillons d'eau, sont indiquées dans la Figure 1. Les écrevisses ont été pêchées à 2 100 m (2ème partie) et 7 100 m (6ème partie) de profondeur.

Depth (m)	Part of the cave	spm	$P\text{-}PO_4$	$N\text{-}NH_4$	SiO_4	$N\text{-}NO_3$
700	2	55.55	0.083	0.020	1.197	0.872
1,500	2	50.18	0.085	0.022	1.237	0.868
2,000	2	63.82	0.086	0.024	0.923	0.896
2,500	3	46.88	0.082	0.025	1.159	0.869
5,100	4	26.55	0.210	1.126	2.357	1.232
6,000	5	92.34	0.088	0.048	1.585	1.848
7,750	6	53.68	0.191	0.076	3.794	0.573

to a small hypogean lake. After 1980, however, there are sediments in this place that cover the cave, probably after a very big storm or heavy rainfall.

HOGGER (1988) points out that the cave environment is relatively stable, the major limitations being flooding and food availability. Hypogean crayfish consequently frequently abandon areas of preferred substrate in favour of concentrations of organic debris. Such concentrations of organic debris are likely to be present in the cave system, but have not so far being quantified. A lot of debris can pass through the swallow holes and probably reach the cave.

Amongst the crayfish families, only members of the Cambaridae have produced obligate troglobites (HOBBS Jr., 1988). In Florida (USA) for example of the 52 species and subspecies known, 13 of them are troglodytes, whilst in southern Indiana six species or subspecies inhabit the subterranean caves in the karst region (HOBBS Jr., 1988; HOGGER, 1988). The most unusual troglobitic crayfish is *Troglocambarus maclanei*, which is primarily a filter feeder and spends much of its life on the submerged ceiling of caves. The most primitive members of the genus *Orconectes* are troglobites, e.g. *O. pelucidus australis*, frequents subterranean waters in a narrow belt from Northern Alabama to Southern Indiana (MOMOT, 1988). If *A. torrentium* is shown to be able to complete its whole life history deep within a cave system it will be the first member of the crayfish family Astacidae to be found to do so. The finding of crayfish so deep inside a cave system is unusual, and is probably the deepest record so far in Europe and North America (Dr J. COOPER; Dr. C. TAYLOR, Dr. H.H. HOBBS, *pers. com*., October 2004).

Both pigmented and unpigmented crayfish have been found occupying caves in North America (HOGGER, 1988). The pigmented species, *Cambarus laevis*, is found in both epigean and hypogean habitats where the maximum temperature is below 20°C. *Orconectes inermis inermis* and *O. i. testii* are, however, unpigmented and generally unresponsive to light. Both subspecies occur in areas of low stream gradient where there are pools and a muddy substrate of silt and detritus. *Orconectes sloanii, O. propinquus* and *O. immunis* have been recorded within the first 100 m of caves, but these are thought to be incursions from epigean populations. *Cambarus tenebrosus* is a pigmented species but with small eyes. The species is found in epigean creeks and near cave and spring openings; however quite frequently individuals of the species will walk several hundred metres back into caves (Dr. C. TAYLOR, *pers. com*., October 2004). The crayfish found in the Aggitis Cave were pigmented, although those from the deeper parts had characteristically bluish pereopods. The brown colour of the crayfish may indicate an allochtonic source of carotenoids, *i.e.* from dead vascular plants or algae, or even amphipods. As mentioned above accumulations of organic matter can occur in caves and may provide a source of food (HOGGER, 1988).

On the European side on the other hand, cases on cave crayfish have been almost unknown or rarely reported (*e.g. A. torrentium* from the Tkalca Jama Cave mentioned in the introduction above is one). From the Škocjanske Jame (= Sankt Canzian) Cave near Divica in Slovenia, *Cambarus typhlobius* Joseph, 1880 was once reported, but this was revealed to be false later (HOLTHUIS, 1964; MACHINO and HOLDICH, in press). In this cave (*i.e.* Škocjanske Jame Cave), *Astacus astacus* (Linnaeus, 1758) was occasionally found (STAMMER, 1932). Also SPANDL (1926) mentioned that, among animals conserved in the Naturhistorisches Museum in Wien, several specimens of *A. astacus* of the Škocjanske Jame Cave were conserved. Under the name of "*Astacus saxatilis*", *Austropopotamobius pallipes* (Lereboullet, 1858) was reported from the same cave (MÜLLER, 1926: p. 68). In the subterranean habitat of Croatia, this species (*A. pallipes)* was reported from the Bakovac spring near Gornji Kosinj and another species (*A. torrentium*) from the Sušik sinkhole near Drežnica and the Kremen sinkhole at Gornji Kremen near Slunj (MAGUIRE and GOTTSTEIN-MATOCEC, 2004). In the Cave of Paros near Paros-Pestere (County of

Hunedoara, Romania), quite a few good-sized specimens of *A. astacus* were caught down to a depth of 300 m according to CHAPPUIS (1927).

ACKNOWLEDGMENTS

This study is part of a project implemented by the Fisheries Research Institute of Kavala, Greece (FRI) and funded by the Prefecture of Drama, Macedonia, Greece. The authors would like to thank the Hellenic Speleological Exploration Club (SPELEO) and Nikos DIAFAS for their valuable help in the deep part of the cave, Lydia KATSAITI and the Aggitis Cave Tourist Development Agency for their help, and the annonymous referees for their useful comments.

REFERENCES

BERON P., 1986. Results of the studies of the cave fauna of Greece. *Biologia Gallo-Hellenica, 12*, 125-131.

BOTT R., 1972. Besiedlungsgeschichte und Systematic der Astaciden West-Europas unter besonderer Berücksichtigung der Schweiz. *Rev. Suisse Zool., 79 (1)*, 387-408 + 4 pl.

CHAPPUIS P.A., 1927. Die Tierwelt der unterirdischen Gewässer. *Die Binengewässer, Vol. 3*, IV + 176 p. + 4 pl. Schweizerbart, Stuttgart.

DIMADI A., XEIDAKIS G., MARINOS P., 1993. Litourgeia karstikon pigon sto Oros Falakro Dramas. Spileo Pigon Aggiti – Maara) (Functioning of karstic spings in Falakro Mountain of Drama. Aggitis Cave – Maara). *Conference Proceedings "Management of Aquatic Resources in the Prefecture of Drama",* p. 35-52. (in Greek)

HOBBS H.H. Jr., 1988. Crayfish distribution, adaptive radiation and evolution. *In*: Freshwater crayfish: biology, management and exploitation, HOLDICH D.M. and LOWERY R.S. (eds), p. 52-82 + 426-479. Croom Helm, London.

HOGGER J.B., 1988. Ecology, population biology and behaviour. *In*: Freshwater crayfish: biology, management and exploitation, HOLDICH D.M. and LOWERY R.S. (eds), p. 114-144 + 426-479. Croom Helm, London.

HOLDICH D.M., 2002. Present distribution of crayfish in Europe and some adjoining countries. *Bull. Fr. Pêche Piscic*., *367*, 611-650.

HOLTHUIS, L.B., 1964. On the status of two allegedly European crayfishes, *Cambarus typhlobius* Joseph, 1880, and *Austropotamobius pallipes bispinosus* Karaman, 1961 (Decapoda Astacidae). *Crustaceana, 7*, 42-48 + pl. 3.

KAPPUS P., PEISSNE T., RAWER-JOST C., 1999. Distribution and habitat conditions of crayfish populations in the urban freshwater systems of Stuttgart (Baden-Württemberg, Germany). *Freshwater Crayfish*, *12*, 778-785.

KINZELBACH R., 1986. The southern limit of the crayfishes species *Astacus torrentium* and *A. astacus* in Greece. *Zoology in the Middle East (Heidelberg)*, *1*, 145-146.

LAURENT P.J., 1988. *Austropotamobius pallipes* and *A. torrentium* with observations on their interactions with other species in Europe. *In*: Freshwater crayfish: biology, management and exploitation, HOLDICH D.M. and LOWERY R.S. (eds), p. 341-364 + 426-479. Croom Helm, London.

MACHINO Y., HOLDICH D.M., 2005. Distribution of crayfish in Europe and adjoining countries: updates and comments. *Freshwater Crayfish*, *15* (in press).

MAGUIRE I., GOTTSTEIN-MATOCEC, S., 2004. The distribution pattern of freshwater crayfish in Croatia. *Crustaceana*, *77*, 25-47.

MOMOT W.T., 1988. *Orconectes* in North America and elsewhere. *In*: Freshwater crayfish: biology, management and exploitation, HOLDICH D.M. and LOWERY R.S. (eds), p. 262-282 + 426-479. Croom Helm, London.

MÜLLER G., 1926. La fauna delle caverne. *In*: Duemilla grotte, quarant'anni di esplorazioni nella Venezia Giulia, BERTARELLI L.V. and BOEGAN E. (eds.), p. 47-74. Touring Club Italiano, Milano.

PARAGAMIAN K., 1994. Axiopoiisi Spilaiou Maara (Development of the Aggitis Cave). Environmental Study. Democritus University of Xanthi, Xanthi, Greece, 45 p. (in Greek).

PETROCHEILOS I., 1952. Spileologikai erevnai eis périochin Kato Nevrokopiou (Speleological research in the area of Kato Nevrokopio). *Deltion Hellinikis Spileologikis Hetaireias (Athens), 1*, 286-293 (in Greek).

REILE P., 2000. Le Karst du Massif du Falakro et la Résurgence de Maaras (Commune de Angitis). Résultats des travaux hydrogéologiques et topographiques. Expédition 2000. Fédération Française de Spéléologie, Paris, France, 66 p.

SPANDL H., 1926. Die Tierwelt der unterirdischen Gewässer. *Speläologische Monographie, vol. 11*, xii + 235 p. Speläologisches Institut, Wien.

SPELEO, 2003. Spileo Pigon Aggiti – Maara. Apostoli 2002-2003 (The Aggitis cave – Maara. Expeditions 2002-2003). Hellenic Speleological Exploration Club (SPELEO), Athens, Greece, 21 p. (in Greek).

STAMMER H.J., 1932. Die Fauna des Timavo - ein Beitrag zur Kenntniss der Höhlengewässer, des Süß- und Brackwassers im Karst. *Zool. Jahrb., Abt. Syst. Ökol. Georgr. Tiere, 63 (5/6)*, 521-656.

THEODOSIADIS T., TZAVELAS G., NIKOLAIDIS S., 2003. Spileo Pigon Aggiti - Maara. (The Aggitis Cave - Maara). *Helliniko Panorama 31*, 128-157 (in Greek).

TRONTELJ P., MACHINO Y., SKET B., 2004. Phylogenetic and phylogeographic relationships in the crayfish genus *Austropotamobius* inferred from mitochondrial COI gene sequences. *Mol. Phylogenet. Evol., 34*, 212-226.

XEIDAKIS G., 1996. Axiopiisi Spilaiou Maara (Development of the Aggitis Cave). Synoptic Geotechnical Study. Democritus University of Xanthi, Xanthi, Greece, 115 p. (in Greek).