

Ber. nat.-med. Verein Innsbruck	Band 89	S. 169 - 178	Innsbruck, Okt. 2002
---------------------------------	---------	--------------	----------------------

A revised determination key of freshwater crayfish in Europe

von

Leopold FÜREDER & Yoichi MACHINO^{*)}

Synopsis: There are many errors on crayfish species determination. Most errors originate from color analyses and false or misleading methods or results mentioned in biological papers. Therefore, after some corrections on former methods and consultations of several museums and institutions, we propose a new key without color analyses for determination of crayfish in Europe.

1. Introduction:

Since more than 100 years several crayfish-determination keys have been published in Europe. Although crayfish species identification does not seem to be so difficult to do (at least to us), in several occasions we encountered museums, crayfish amateurs and "self-called specialists" who made wrong determinations. Even worse, some wrong keys have been accepted and published. Furthermore, some papers even mention that identifying crayfish species may not be so easy. We have even met students, studying crayfish, who did not (or could not) determine crayfish species by simple external characteristics but by genetic markers. For us, who think the determination is not a "philosophy", these "absurd" situations should not be ignored. These facts and the existence of errors in the literature are the reasons why we are providing another determination key for freshwater crayfish in Europe.

However, since we have not had many occasions to observe the two *Astacus* taxa *Astacus pachypus* RATHKE, 1837 and *Astacus pylzowi* (SKORIKOV, 1907), we will not – although one is mentioned briefly - detail these two crayfish species in the present paper. Also since new exotic species may exist in Europe beyond our knowledge, we do not want to detail exotic crayfish other than briefly mentioning them. We ignore the exact number how many species from North America and Australia may already have been established in European waters. *Pacifastacus leniusculus* (DANA, 1852), *Orconectes limosus* (RAFFINESQUE, 1817), *Orconectes immunis* (HAGEN, 1870), *Procambarus clarkii* (GIRARD, 1852) and *Cherax destructor* CLARK, 1936 are reported to have already been established, possibly other species did too (see DOST 1995; DEHUS et al. 1999; GUTIÉREZ-YURRITA et al. 1999).

^{*)} Anschrift der Verfasser: Leopold Füreder, Institut für Zoologie und Limnologie, Universität Innsbruck, Technikerstraße 25, A-6020 Innsbruck, Austria, Yoichi Machino, 13 Rue Montorge, F-38000 Grenoble, France.

2. Origins of errors:

Most errors originate from determining species by color patterns or by uncritical adoption of information in published papers.

Crayfish color is known for its great variation. For example, the lower side of chela of white-clawed crayfish *Austropotamobius pallipes* (LEREBoulLET, 1858) is not always white. It may vary from white, green, blue even to orange. Inversely, the lower side of chela can be red in noble crayfish *Astacus astacus* (LINNAEUS, 1758), narrow-clawed crayfish *Astacus leptodactylus* ESCHSCHOLTZ, 1823, signal crayfish (*P. leniusculus*), and red swamp crayfish (*P. clarkii*). Once cooked or long preserved in formalin or alcohol the colour may change completely. But the determination is not prevented at all, because color patterns are of secondary importance.

Crayfish papers may also be a source of errors. As mentioned above, those suggesting the importance of coloration to distinguish between species are typical origins for false identifications. Indication of the number of postorbital ridges can lead to errors too. When comparing postorbital ridges of *A. astacus* (2 pairs of postorbital ridges) of the northern form (*A. a. astacus*, sensu KARAMAN 1963) and those of *A. pallipes* (1 pair of postorbital ridges) of the Italian form (*A. p. italicus*), sometimes the distinction is not so clear with this character. Occasionally good determination keys are erased or updated by bad ones. Although ENTZ (1909, 1914), BOTT (1950) and KARAMAN (1962, 1963) correctly mentioned the presence of talon on pleopod 2 in males of *A. leptodactylus*, some later papers mentioned its absence. The talon on pleopod 2 in males of *Austropotamobius torrentium* (SCHRANK, 1803) is mentioned correctly in ENTZ (1909, 1914) and later detailed by ALBRECHT (1982) as absent in the western form while present in the eastern form, but many papers mention all *A. torrentium* without talon. Even crayfish size is sometimes absurdly used by certain amateurs to determine individual species.

Tab.1: Examples of determination errors

False species	Correct species	Error encountered
<i>A. astacus</i>	<i>A. leptodactylus</i>	museum (the Netherlands)
<i>A. leptodactylus</i>	<i>A. astacus</i>	specialist (France & Ukraine)
<i>A. astacus</i>	<i>A. pallipes</i>	amateur (France)
<i>A. pallipes</i>	<i>A. astacus</i>	specialist (Italy)
<i>A. pallipes</i>	<i>A. leptodactylus</i>	amateur (Belgium)
<i>A. pallipes</i>	<i>A. torrentium</i>	specialist (Austria, France & Italy)
<i>A. torrentium</i>	<i>A. pallipes</i>	museum (France), specialist (Austria)
<i>A. astacus</i>	<i>P. leniusculus</i>	amateur (Luxembourg & France), specialist (Italy)
<i>A. pachypus</i>	<i>P. leniusculus</i>	museum (Germany)
<i>A. pallipes</i>	<i>P. clarkii</i>	museum (Germany)

The listed errors in Table 1 indicate how frequently misidentifications even by specialists occur. To overcome or avoid most uncertainties, we propose several prerequisites and characteristics for correct designations:

- see the samples with your own eyes (although trivial and fundamental, not always practiced)
- better use bigger specimens than small ones: morphology becomes more visible
- better use males than females: male's pleopods 1 & 2 are useful, chelae become bigger in mature males
- cephalothorax, chelae and male's pleopods 1 & 2 should be intact

If the points mentioned above are respected, in most cases for European crayfish one will get the correct determination even if only clear photographs (even black and white) of anterior cephalothorax and the upper side of chela are available.

Sometimes females of *A. astacus* and *A. leptodactylus* may pose a problem, but this easily can be avoided by considering associated male specimens. However, some may say that the problem exists because of hybrid between *A. astacus* and *A. leptodactylus*, as mentioned in CUKERZIS (1970). His original experiments (CUKERZIS 1964) showed how difficult it was to obtain hybrid larvae of *A. astacus* and *A. leptodactylus* (however, he concluded that hybrids were possible) (see also FURRER et al. 1999). Actually CUKERZIS obtained some young larvae, but he failed to verify whether the larvae were the hybrid and viable. On the other hand, his criteria for distinguishing the two species were based on shape of chela, coloration, cephalothorax surface and rostral borders (CUKERZIS 1964). But these characteristics can cause confusion when variation appears (and it does), particularly in *A. leptodactylus* (e.g. see BRODSKII 1973/1977, 1981). Also in France, a hybrid population between *A. astacus* and *A. leptodactylus* once occurred reportedly. Based on female samples, morphological study showed the population as hybrid. But later, with male samples, it was revealed as *A. leptodactylus*. As far as we know about hybridization of European crayfish, only the paper of BRODSKII (1980) seems to be valid, who reports a hybrid between *A. leptodactylus* and *A. pachypus*. We think the problem of natural hybridization is excluded for most cases in European crayfish.

In fact, when looking at crayfish, it can easily be learned to determine its exact species by simple observations of the shape of rostrum and chela's surface. If still unconfident, then other characters like pleopods 1 & 2 of males, cervical grooves, etc. (see list below) may help. Following meticulously determination keys mentioned in biological books often may lead to errors, particularly when insisting too much on the form of chela, on the number of postorbital ridges, or coloration. Therefore, we list morphological characters most appropriate to help determining the individual species (Table 2, Figs. 1 to 9). Colour characteristics are not mentioned since they may cause confusion. Below is a list of morphological characters we usually apply. Those in bold letters appear to be the most important and discriminatory.

Table 2: Synoptic determination key of crayfish in Europe. Areas surrounded by thick lines include priority characters for achieving correct species identifications.

Species	Acumen	Rostral borders	Rostral cresta median	Spine on antennular precoxa	Denticulation on the lower surface of scale	Chela surface granulation	Postorbital ridge	Hepatic spines	Spines on cervical grooves	Branchio-cardiac grooves	Pleopod 1 in ♂	Talon on pleopod 2 in ♂
<i>A. astacus</i>	prominent	parallel or trapezoid	present with spines		absent	big	2 pairs (sometimes 2nd pair almost not visible)	absent	present	present		absent
<i>A. leptodactylus</i>	prominent	parallel or trapezoid; denticulated or not	present with or without spines		absent	big	2 pairs	present or absent	present			present
<i>A. pachypus</i>	prominent	parallel (or trapezoid ?)	present		absent		2 pairs	absent	present			present
<i>A. pallipes</i>	small or prominent	triangle or trapezoid	present	present	absent	small	1 pair (sometimes 2nd pair slightly visible)	absent	present			present
<i>A. torrentium</i>		triangle	present or slightly absent	absent or present	present	very big	1 pair	absent	absent	absent		absent or present
<i>O. limosus</i>	prominent	parallel	absent	present	absent		1 pair	present	present			absent
<i>P. leniusculus</i>	prominent	parallel	present	absent	absent	very small and smooth	2 pairs	absent	absent			absent
<i>P. clar-kii</i>		triangle	absent	absent	absent	very big	1 pair	absent			both grooves unify and areola disappears	very pointed
<i>O. immunitis</i>		triangle					1 pair	absent				
<i>C. destructor</i>	almost absent	triangle	absent		absent	very smooth	1 pair	absent	absent	absent		

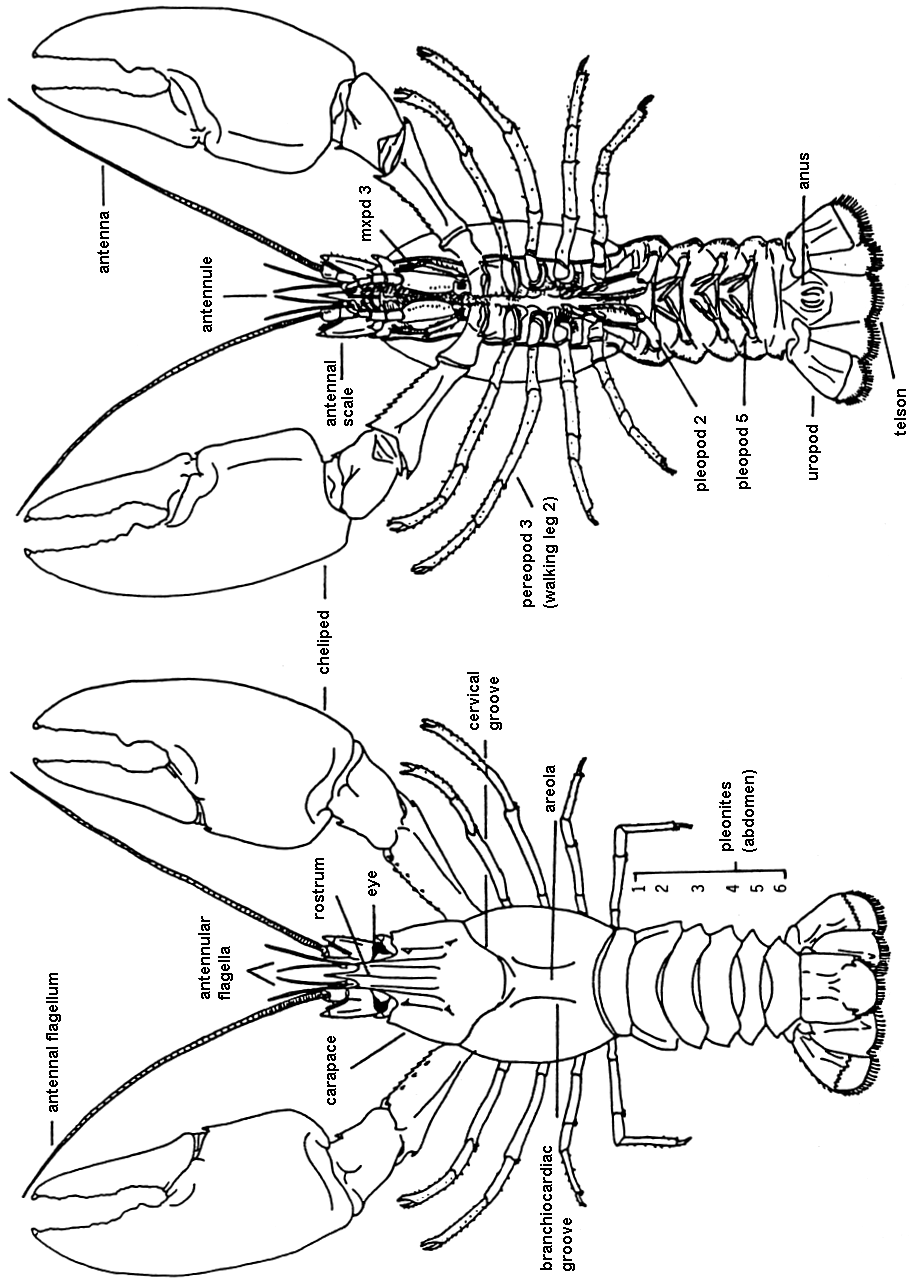


Fig. 1: General morphology of crayfish (HOLDICH & REEVE 1988).

Astacus astacus

- **Rostral cresta median very distinct with visible spines forming denticulation**
- **Rostral borders parallel or trapezoid**
- Two pairs of postorbital ridges (sometimes the 2nd pair is not visible in the northern form, *A. a. astacus*)
- Chela's granulation big and surface rough
- **Pleopod 2 in male without talon**
- (confusion occurred in females between this species and *A. leptodactylus*)

Astacus leptodactylus

- Rostral cresta median visible and with or without spines
- **Rostral borders parallel or trapezoid, with or without denticulation**
- Two pairs of postorbital ridges
- Hepatic spines present or absent
- Chela's granulation big
- **Pleopod 2 in male with talon**
- (confusion occurred in females between this species and *A. astacus*)

Astacus pachypus

- Rostral cresta median visible and without spines (or almost)
- Rostral borders parallel (or trapezoid ?)
- Two pairs of postorbital ridges
- Chela's granulation small
- Pleopod 2 in male with talon
- (It's like a mixed morphology: rostrum and postorbital ridges of *A. leptodactylus* and chelae of *A. pallipes*)

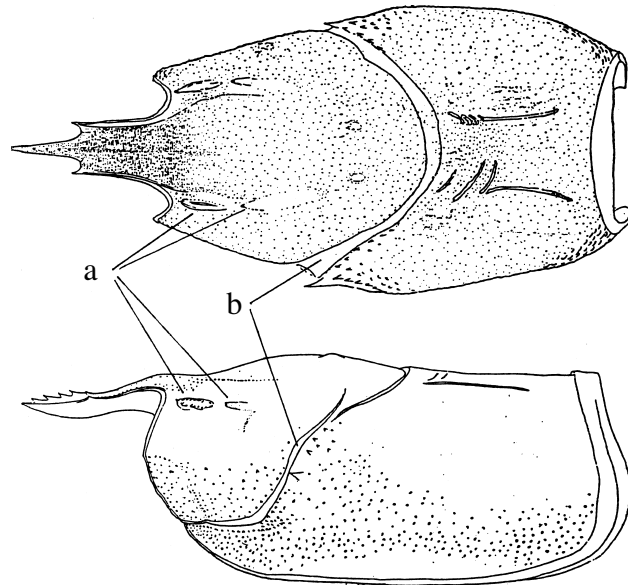
Austropotamobius pallipes

- Rostral cresta median visible
- **Rostral borders triangle or trapezoid**
- One pair of postorbital ridges (sometimes a 2nd pair is slightly visible in the Italian form, *A. p. italicus*)
- **Chela's granulation small**
- Pleopod 2 in male with talon

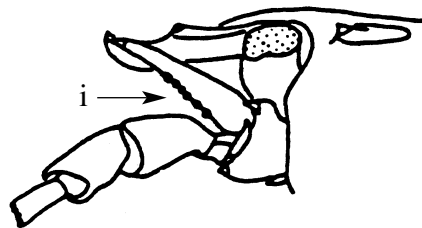
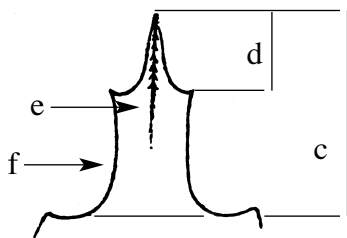
Austropotamobius torrentium

- Rostral cresta median visible or slightly
- **Rostral borders triangle**
- One pair of postorbital ridges
- **Cervical grooves without spines**
- **Lower surface of scales with denticulation**
- **Chela's granulation very big and surface very rough**
- Pleopod 2 in male with or without talon (present in the eastern form and absent in the western form)

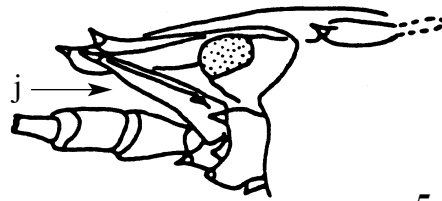
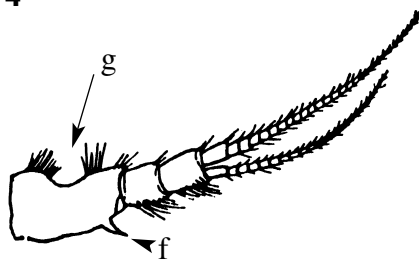
2



3



4



5

Fig. 2 - 5:

2 Cephalothorax of *A. astacus* (ENTZ 1909); a postorbital ridges; b cervical grooves. 3 Rostrum of crayfish (CARL 1920); c rostrum, d acumen (=triangular apex), e rostral cresta median, f rostral border. 4 Antennule of crayfish (CARL 1920); g pre-coxa, h spine. 5 Scale or antennal exopod (ALBRECHT 1982); i scale with denticulation in *A. torrentium*, j scale without denticulation in *A. pallipes*.

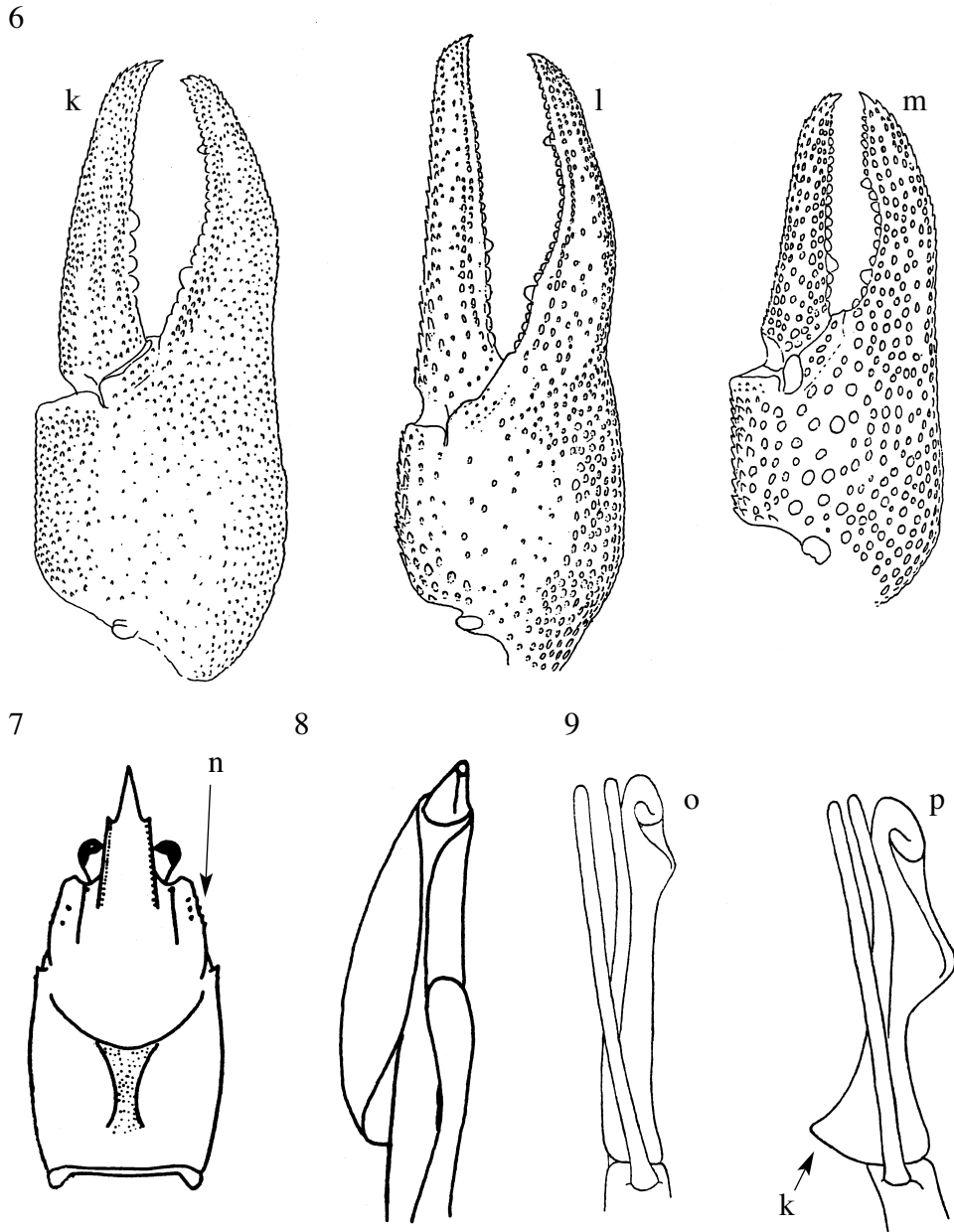


Fig. 6 - 9:
6 Crayfish chela (ENTZ 1909); k *A. pallipes*, l *A. astacus*, m *A. torrentium*. 7 Cephalothorax of *O. limosus* (HOBBS 1972); n hepatic spines. 8 Pleopod 1 in male of *P. leniusculus* (VIGNEUX 1981). 9 Pleopod 2 in crayfish male (BOTT 1950); o *A. astacus* without talon, p *A. leptodactylus* with talon, q talon.

Orconectes limosus

- Rostral cresta median absent
- Rostral borders parallel
- **Hepatic spines present**

Pacifastacus leniusculus

- Rostral cresta median visible
- Rostral borders parallel
- Two pairs of postorbital ridges
- Cervical grooves without spines
- **Chela's granulation very small and surface smooth**
- **Pleopod 1 in male very pointed**

Procambarus clarkii

- Rostral cresta median absent
- Rostral borders triangle
- Cervical grooves without spines
- Branchiocardiac grooves of both sides converge and unify, leaving areola almost non-existent
- Chela's granulation extremely big (even forming spines)

3. Conclusion:

When we began crayfish studies in 1994, we followed meticulously determination keys we learned at universities or found in books, like other students. With increasing experience, now we start to see there are easier ways to determine. Without colour description and statistics, the crayfish determination can be done easily and correctly by simple external morphological features, at least on the specific level.

Misidentifications are even frequently encountered associated with exotic species. Besides incorrect information on the ecological and distribution of individual species, false determination increases the risk to transmit vectors or agents of crayfish disease (like crayfish plague). Still today several examples of *P. leniusculus* identified as *A. astacus* circulate in well distributed books. Further and continuous education on crayfish identification at amateur and professional level may overcome reported inadequacies.

Acknowledgements: We thank H. Albrecht, H. Andres, D. Holdrich and E. Vigneux for their help.

4. References:

- ALBRECHT, H. (1982): Das System der europäischen Flußkrebse (Decapoda, Astacidae): Vorschlag und Begründung. Mitt. Hamb. Zool. Mus. Inst., **79**: 187 - 210. Hamburg.
- BOTT, R. (1950): Die Flußkrebse Europas (Decapoda, Astacidae). Abh. Senckenb. Naturforsch. Ges., 483: 1-36 + 6 Tafeln. Frankfurt am Main.
- BRODSKII, S.Ya. (1973/1977): Rechnye raki (Crustacea, Astacidae) Sovetskogo Soyuza. Vestnik Zoologii, 1973, **6** (4): 49 - 53; 1974, 7 (4): 51 - 59; 1974, 7 (6): 43 - 49; 1976, 9 (4): 14 - 19; 1977, 10 (3): 48 - 53. Kiev.
- BRODSKII, S.Ya. (1980): Prirodnyi gibrid tolstopalogo i dlinnopalogo rechnykh rakov (Decapoda, Astacidae). Vestnik Zoologii, **13** (1): 86 - 88. Kiev.

- BRODSKII, S.Ya. (1981): Richkovi raky. Fauna Ukrainy, 26 (3): 211 p. Naukova Dumka, Kyiv.
- CARL, J. 1920. Decapodes. Catalogue des Invertébrés de la Suisse, (12): iii + 35 p. Georg, Genève.
- CUKERZIS, J.M. (1964): O mezhhvidovykh otnosheniyakh shirokopalogo (*Astacus astacus* L.) i dlin-nopalogo (*Astacus leptodactylus* Esch.) rakov v ozerakh vostochnoi Litvy. Zoologicheskii Zhurnal, 43 (2): 172-177. Moskva.
- CUKERZIS, J.M. (1970): Biologiya shirokopalogo raka. Mintis, Vilnius. 207 p. French translation from Russian by N. Zuzine in 1984. La biologie de l'écrevisse (*Astacus astacus*). Institut National de la Recherche Agronomique, Paris. 313 p.
- DEHUS, P., S. PHILLIPSON, E. BOHL, B. OIDTMANN, M. KELLER & S. LECHLEITER (1999): German conservation strategies for native crayfish species with regard to alien species, p. 149-159. In F. GHERARDI & D.M. HOLDICH [eds.], Crayfish in Europe as alien species: how to make the best of a bad situation ? Crustacean Issues, vol. 11. A.A. Balkema, Rotterdam.
- DOST, U. (1995): Flußkrebs im Aquarium. Die Aquar.-Terr. Z. (DATZ), 48 (10): 502 - 508. Stuttgart.
- ENTZ, G. (1909): A. magyarországi folyami rákokról. Állattani Közlemények, 8: 37 - 52 + 95 + 97 - 110 + 147 + 149 - 163 + 198 - 199 + tábla 4 - 7. Budapest.
- ENTZ, G. (1914) : Über die Flußkrebse Ungarns. Math. Naturwiss. Ber. Ungarn, Jahrgang 1912, 30: 67 - 127 + 4 Tafeln. Leipzig.
- FURRER, S.C., M. CANTIENI & N. DUVOISIN (1999): Freshly hatched hybrid between *Astacus astacus* and *Astacus leptodactylus* differ in chela shape from purebred offspring, p. 90 - 97. In M. KELLER, M.M. KELLER, B. OIDTMANN, R. HOFFMANN & G. VOGT [eds.], Freshwater Crayfish, vol. 12. Weltbild Verlag, Augsburg.
- GUTIÉRREZ-YURRITA, P.J., J.M. MARTÍNEZ, M.Á. BRAVO-UTERA, C. MONTES, M. ILHÉU & J.M. BERNARDO (1999): The status of crayfish populations in Spain and Portugal, p. 161 - 192. In F. GHERARDI & D.M. HOLDICH [eds.], Crayfish in Europe as alien species: how to make the best of a bad situation ? Crustacean Issues, vol. 11. A.A. Balkema, Rotterdam.
- HOBBS, H.H., Jr. (1972): Crayfishes (Astacidae) of North and Middle America. Water Pollut. Control Res. Ser., 9: x + 173 p. Washington, D.C.
- HOLDICH, D.M., & I.D. REEVE (1988): Functional morphology and anatomy, p. 11 - 51 + 426 - 479. In D.M. HOLDICH & R.S. LOWERY [eds.], Freshwater crayfish: biology, exploitation and management. Croom Helm, London.
- KARAMAN, M.S. (1962): Ein Beitrag zur Systematik der Astacidae (Decapoda). Crustaceana, 3: 173 - 191. Leiden.
- KARAMAN, M.S. (1963): Studie der Astacidae (Crustacea, Decapoda). Hydrobiologie, 22: 111 - 132. The Hague.
- VIGNEUX, E. (1981) : Détermination rapide des écrevisses. Bull. Fr. Piscic., 53 (281): 185 - 210. Boves (Somme).