

Short Communication

The genus *Artemia* Leach, 1819 (Crustacea: Branchiopoda). I. True and false taxonomical descriptions

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ABSTRACT. The brine shrimp *Artemia* is important for aquaculture since it is highly nutritious. It is also used widely in biological studies because it is easy to culture. The aim of the present study is to review the literature on the taxonomical nomenclature of *Artemia*. The present study indicates the existence of seven species: three living in the Americas, one in Europe, and three in Asia.

Keywords: *Artemia*, saline lakes, morphology, species, taxonomy.

El género *Artemia* Leach, 1819 (Crustacea: Branchiopoda). I. Descripciones taxonómicas verdaderas y falsas

RESUMEN. El camarón de salmuera *Artemia* es importante para la acuicultura por su alta calidad nutricional y es muy utilizado para estudios biológicos por ser de fácil cultivo. El objetivo del presente estudio es revisar la literatura sobre la nomenclatura taxonómica de *Artemia*. Se determina la existencia de siete especies; tres de ellas viven en América, una en Europa y tres en Asia.

Palabras clave: *Artemia*, lagos salinos, morfología, especies, taxonomía.

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The brine shrimp *Artemia* is one of the most important aquatic animals used in aquaculture industry. It was first reported from Urmia Lake in 982 by an unknown Iranian geographer (Asem, 2008), and then in 1756 Schlösser pictured both sexes clearly. Linnaeus (1758) described it as *Cancer salinus* but 61 years later, Leach (1819) transferred it to *Artemia salina*.

The taxonomic status of the genus *Artemia* is as follows (Martin & Davis, 2001):

Subphylum: Crustacea Brünnich, 1772

Class: Branchiopoda Latreille, 1817

Subclass: Sarsostraca Tasch, 1969

Order: Anostraca Sars, 1867

Family: Artemiidae Grochowski, 1896

Genus: *Artemia* Leach, 1819

- *A. salina* (Linnaeus, 1758): Mediterranean area
- *A. monica* Verrill, 1869: USA (Mono Lake; California)

- *A. urmiana* Günther, 1899: Iran (Urmia Lake; West Azerbaijan Province)
- *A. franciscana* Kellogg, 1906: America, Caribbean and Pacific islands
- *A. persimilis* Piccinelli & Prosdocimi, 1968: South America
- *A. sinica* Cai, 1989: Central and Eastern Asia
- *A. tibetiana* Abatzopoulos, Zhang & Sorigeloos, 1998: China (Tibet)
- *Artemia* sp. Pilla & Beardmore, 1994: Kazakhstan
- Parthenogenetic population(s) of *Artemia*: Europe, Africa, Asia and Australia

Taxonomists are still confused about the systematic and phylogenetic relationships of the *Artemia* species (Triantaphyllidis *et al.*, 1997) and there are different opinions about its biosystematics. For example, there are two views for *A. franciscana*

Table 1. True and false taxonomic expression on the genus *Artemia*.
Tabla 1. Expresión verdadera y falsa taxonómica sobre el género *Artemia*.

Taxon	Status	False decision	Comment	True decision	Comment
<i>Artemia</i>		<i>Artemia</i> L., 1758	1		
		<i>Artemia</i> (L., 1758)	2		
	Genus	<i>Artemia</i> Linnaeus, 1758	3	<i>Artemia</i> Leach, 1819	6
		<i>Artemia</i> (Linnaeus, 1758)	4		
		<i>Artemia</i> (Leach, 1819)	5		
<i>Artemia salina</i>		<i>Artemia salina</i> L., 1758	7		
	Species	<i>Artemia salina</i> Linnaeus, 1758	8	<i>Artemia salina</i> (L., 1758)	11
		<i>Artemia salina</i> Leach, 1819	9	<i>Artemia salina</i> (Linnaeus, 1758)	12
		<i>Artemia salina</i> (Leach, 1819)	10		
<i>Artemia monica</i>	Species	<i>Artemia monica</i> (Verrill, 1869)	13	<i>Artemia monica</i> Verrill, 1869	15
	Sibling species	<i>Artemia franciscana monica</i>	14	<i>Artemia monica</i> Verrill, 1869	16
<i>Artemia urmiana</i>		<i>Artemia urmiana</i> (Günther, 1900)	17		
		<i>Artemia urmiana</i> (Günther, 1890)	18		
	Species	<i>Artemia urmiana</i> (Günther, 1899)	19	<i>Artemia urmiana</i> Günther, 1899	22
		<i>Artemia urmiana</i> Günther, 1900	20		
		<i>Artemia urmiana</i> Günther, 1890	21		
	Species	<i>Artemia franciscana</i> (Kellogg, 1906)	23	<i>Artemia franciscana</i> Kellogg, 1906	25
<i>Artemia franciscana</i>	Sibling species	<i>Artemia franciscana franciscana</i>	24	<i>Artemia franciscana</i> Kellogg, 1906	26
	population	<i>Artemia parthenogenetica</i>	27	parthenogenetic population(s) of <i>Artemia</i>	28
<i>Artemia persimilis</i>	Species	<i>Artemia persimilis</i> (Piccinelli & Prosdocimi, 1968)	29	<i>Artemia persimilis</i> Piccinelli & Prosdocimi, 1968	30
		<i>Artemia sinica</i> (Cai, 1989)	31		
<i>Artemia sinica</i>	Species	<i>Artemia sinica</i> (Yaneng, 1989)	32	<i>Artemia sinica</i> Cai, 1989	33
		<i>Artemia sinica</i> Yaneng, 1989			
<i>Artemia sinica sinica</i>	Sub-species	<i>Artemia sinica sinica</i> Zhou et al., 2003	34	<i>Artemia sinica sinica</i> Cai, 1989	35
		<i>Artemia sinica sinica</i> Zhou, et al., 2003			
<i>Artemia tibetiana</i>	Species	<i>Artemia tibetiana</i> (Abatzopoulos et al., 1998)	36	<i>Artemia tibetiana</i> Abatzopoulos, et al., 1998	37
		<i>Artemia tibetiana</i> Abatzopoulos et al., 1998		<i>Artemia tibetiana</i> Abatzopoulos et al., 1998	
<i>Artemia sinica tibetiana</i>	Sub-species	<i>Artemia sinica tibetiana</i> Zhou et al., 2003	38	<i>Artemia sinica tibetiana</i> Abatzopoulos et al., 1998	39
		<i>Artemia sinica tibetiana</i> Zhou, et al., 2003		<i>Artemia sinica tibetiana</i> Abatzopoulos, et al., 1998	

Comments:

NOTE: The “*comma*” must be used between the name of the author and date [Art. 22; (ICZN, 2000)].

- 1, 2, 3, 4: The genus *Artemia* was described by Leach in 1819 not Linnaeus. Linnaeus, C. 1758. *Systema naturae*. Hofniae, 1: 634.
- 5: Leach described *Artemia* so parentheses should not be used.
- 6: Leach had described the genus *Artemia* in 1819 so it should be depicted as: *Artemia* Leach, 1819
- Leach, W.E. 1819. *Entomotraca*, Dictionnaire des Science Naturelles, 14, 524.
- 7, 8: Although Linnaeus (1758) described the brine shrimp as *Cancer salinus* and Leach has corrected its status as *Artemia salina* in 1819, according to Article 22: 22A.3. (ICZN 2000) the only true status will be: *Artemia salina* (L. 1758) or *Artemia salina* (Linnaeus, 1758). Use of parentheses around author's name shows Linnaeus had described this species in a different genus in 1758 and then it has been changed into *Artemia salina*.
- NOTE: Article 22: 22A.3. Date in a changed combination (ICZN, 2000). When the original date of publication of a species-group name is cited with the name in a changed combination, the date should be enclosed within the same parentheses as the name of the original author [Art. 51.3; (ICZN 2000)].
- 9, 10: Although the rule of Article 22: 22A.3. (ICZN, 2000) is respected but punctuation mark “()” is absent. Because Linnaeus had used a different name for *Artemia* therefore according to Article 22: 22A.3. (ICZN, 2000), Linnaeus and its date must be put in parenthesis.
- 11, 12: These two expressions conform that Linnaeus had considered *Artemia salina* in another genus and was corrected afterward. So, use of parentheses around author name and date is necessary.
- 13: Verrill is the original describer of *Artemia monica* therefore use of parentheses is incorrect.
- 14: Verrill is the original describer of *Artemia monica* therefore the name is: *Artemia monica* Verrill, 1869
- Verrill, A.E. 1869. Contributions to zoology from the museum of Yale College. III. Descriptions of some new America Phyllopod Crustacea, Am. J. Sci. Arts, 142: 244-254.
- 15, 16: Although there is debate about *Artemia* in Mono Lake being a biological or sibling species, trinomial nomenclature is used only for subspecies (see Article 4.; ICZN, 2000). So the proper name is: *Artemia monica* Verrill, 1869
- 17, 18, 19, 20, 21, 22: Günther (1899, not 1900) is the original describer of *Artemia urmiana* so use of parentheses around author name and date is incorrect.
- NOTE: Günther's manuscript has been published in The Journal of the Linnean Society (Zoology) in volume 27. The date of publication is 1899. Günther's article has been printed in issue 177 with actual publication date in December 1899. Günther described *Artemia urmiana* in page 395. The correct reference for this manuscript is:
- Günther, R.T. (1899) Crustacea. pp: 394-399. In: R.T. Günther (ed.). Contributions to the Natural History of Lake Urmi, N.W-Persia, and its Neighbourhood. The Journal of Linnean Society (Zoology), 27(177): 345-453.
- 23: Kellogg had reported and described *Artemia franciscana* from San Francisco Bay in 1906 so there is no need for parentheses.
- 24: Kellogg is the original describer of therefore the proper name is: *Artemia franciscana* Kellogg, 1906
- Kellogg, V.L. 1906. A new *Artemia* and its life condition. Science, 24: 594-596.
- 25: Though even *Artemia* from San Francisco Bay is accepted as sibling species its name will be: *Artemia franciscana* Kellogg, 1906 because “*Trinomial Nomenclature*” used only for subspecies (see Article 4; ICZN, 2000).
- 26: Sibling species are defined under the “*Binomial Nomenclature*” system (see Article 4.; ICZN, 2000).
- 27, 28: The asexual populations had been named such as biological species; *Artemia parthenogenetica* by Barigozzi in 1974 (Browne & Bowen, 1991). Since their reproductive

mechanism is via parthenogenesis and the males seldom are produced in these populations. Therefore, they are introduced as "parthenogenetic *Artemia* populations" (Abatzopoulos *et al.*, 2002)

- 29: Piccinelli & Prosdocimi are the original describers of *Artemia persimilis* in 1968 so parentheses are not needed.
- Piccinelli, M. & T. Prosdocimi. 1968. Descrizione tassonomica delle due specie *Artemia salina* L. e *Artemia persimilis* n.sp. *Genetica*, 102: 113-118.
- 30: The proper name is: *Artemia persimilis* Piccinelli & Prosdocimi, 1968
- 31: Cai is original describer of *Artemia sinica* in 1989 from China so parentheses are not needed.
- Cai, Y. 1989. New *Artemia* sibling species from PR China. *Artemia Newslett.*, 11: 40-41.
- 32: Yaneng is the first name of Cai; but sometimes *Artemia sinica* is cited and referred by Yaneng which it will be false.
- 33: The proper name is: *Artemia sinica* Cai, 1989
- 34, 35: *Artemia sinica* had been described by Cai and Zhou *et al.* has been introduced as two subspecies. New subspecies must be expressed as: *Artemia sinica sinica* Cai, 1989, because Zhou *et al.*, 2003 has done nothing but change the rank.
- 36, 37: Abatzopoulos *et al.* have introduced *Artemia tibetiana* in 1998 from Tibet so use of parentheses around author name and date won't be true status. Its right status only will be: *Artemia tibetiana* Abatzopoulos *et al.*, 1998 or *Artemia tibetiana* Abatzopoulos, Zhang & Sorgeloos, 1998 (See also Recommendation 51C; ICZN, 2000)
- Abatzopoulos, T.J., B. Zhang & P. Sorgeloos. 1998. International study on *Artemia*: 59. *Artemia tibetiana*: preliminary characterization of a new *Artemia* species found in Tibet (People's Republic of China). *Int. J.Salt Lake Res.*, 7: 41-44.
- 38, 39: Abatzopoulos *et al.* (1998) described *Artemia tibetiana* and later Zhou *et al.* (2003) described the subspecies *Artemia sinica tibetiana*. New subspecies must be expressed: *Artemia sinica tibetiana* Abatzopoulos *et al.*, 1998 or *Artemia sinica tibetiana* Abatzopoulos, Zhang & Sorgeloos, 1998. Because Zhou *et al.*, 2003 has only changed the rank (See also Recommendation 51C; ICZN, 2000).

and *A. monica*. *Artemia monica*, from Mono Lake, cannot be crossed with *A. franciscana* because of the inability of the two species to tolerate the same water ionic composition (Mono Lake has a mix of Cl^- , SO_4^{2-} and CO_3^- ions). *A. monica* is therefore thought to be effectively debarred from exchanging gene with *A. franciscana* so these two species are known as two different "biological species" (Clark & Bowen, 1976). According to others (Abreu-Grobois & Beardmore, 1982; Triantaphyllidis *et al.*, 1998), *A. monica* may be ecologically separated from *A. franciscana*, but the genetic distance between these two taxa is less than the distance between other *Artemia* taxa; therefore they can be described as sibling species. Furthermore, there are no taxonomic identification keys for the genus due to a lack of reliable morphological characters, so different methods have been used for species characterization. The most relevant methods are comparison of biometric characteristics, electrophoretic patterns of different allozymes, cross-fertility tests and microscopic survey of the morphology such as frontal knob and gonopod (Abreu-Grobois & Beardmore, 1982; Mura, 1990; Hontoria & Amat, 1992; Triantaphyllidis *et al.*, 1997; De los Ríos & Zúñiga, 2000; Torrentera & Belk, 2002; De los Ríos & Asem, 2008).

Seeing that *Artemia* was an economically important species this has led to a decline of basic studies on this taxon, with wide use of "*Artemia salina*" as a trade name. There are numerous published data on biochemical, mutational, toxicological and others aspects of *Artemia*, all using the name *Artemia salina* for any population in this genus (Abreu-Grobois & Beardmore, 1982; Gajardo *et al.*, 2002). As a result, the brine shrimp *Artemia* is used in many aquaculture studies and for experimental models but its basic taxonomy is not considered by many authors resulting in taxonomical confusion (Table 1), with the mistakes and respective corrections about systematic nomenclature.

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