

## The Status of the Twaite Shad, *Alosa agone*, in Italy and the Western Balkans

Pier Giorgio Bianco\*

Dipartimento di Zoologia, Università Federico II, Via Mezzocannone 8, I-80134 Napoli, Italy.

With 7 figures and 5 tables

**Keywords:** Twaite shad, Italy, western Balkans, variability, biology, taxonomy.

**Abstract.** The twaite shad, *Alosa agone*, is still quite common in Italy and the western Balkans, but locally is endangered or extinct. Two eco-phenotypes are recognized: the migratory ‘Cheppia’ or ‘Laccia’ and the landlocked ‘Agone’. The two forms have never been in contact, at least in Italy. The migratory form is more endangered since barriers and dams prevent it from reaching upstream spawning grounds. A few reproductive communities are documented, e. g. in the Po River in Italy and Neretva River in Croatia. Resident stocks have increased to substantial populations in the large lakes of Italy, especially in the last ten years, probably as a result of improved water quality. The landlocked form from northern Italy was successfully introduced into lakes of central Italy about 75 years ago. In Sardinia a population derived from the migratory form was established about 80 years ago in the artificial Lake Omodeo. In Croatia the ‘Cheppia’ seems to live only in the lower course of the Neretva River. In Montenegro, ‘Cheppia’ and ‘Agone’ live in sympatry in Lake Skadar, but a dam built in 1960 caused a strong decline of both forms. The twaite shad is a very variable species, able to modify its morphology and biology according to its adaptation to freshwater or marine biotopes. In the Mediterranean area, only one taxon should be then recognized, *Alosa agone* (Scopoli, 1786). This will replace *Alosa fallax* (Lacépède, 1803), a taxon described from the Atlantic drainage area which seems to be distinct from Mediterranean populations. A survey of the distribution of reproductive communities of the migrating form in the Mediterranean area must be carried out.

\* Author to whom correspondence should be addressed: gibianco@unina.it

## Problem

The present distribution of reproductive communities and the conservation status of the twaite shad, *Alosa agone* (Scopoli, 1786), in central and eastern Mediterranean areas are still poorly known, especially in the eastern Adriatic drainage basins in Croatia, Montenegro, Albania and the Former Yugoslavian Republic of Macedonia (FYROM). This species, which is mainly amphibiotic, is able to form landlocked populations. The landlocked form is frequent in several lakes of northern Italy where, after a long period of progressive decline (Gandolfi *et al.*, 1991), it has now become reestablished, probably as result of improved water quality (Negri, 1993; Grimaldi, 1997; Confortini, 1998). In the eastern Adriatic drainages in Croatia, Montenegro, Albania and FYROM, the landlocked form is present in two or three lakes.

In the past, migratory populations were common in all coastal areas (Scotti, 1897; MAF, 1931; Ferrero, 1951; Vukovic, 1961; Tortonese, 1970; Ivanovic, 1973) and spawning occurred in the lower courses of medium- and large-sized rivers. Today the global situation of the migratory form, which has little commercial value, is poorly known since it is often not included as a distinct species in yearly fishing statistics. The species is very seldom if not extinct in the Ebro River, (B. Elvira, pers. comm.), the only western Mediterranean basin of the Iberian Peninsula where the species still exists (Elvira, 1995). In France, the populations of the amphibiotic form are now progressively increasing due to conservation measures and construction of fish ladders on dams, especially along the Rhône River (Le Corre *et al.*, 2000). In Greece, its presence is documented for at least four rivers: Evros, Nestos, Strymon and Pinnios (Bobori *et al.*, 2000), but no information is available about its conservation status, ecology and biology.

Recent data concerning the pan-Mediterranean distribution and conservation of the twaite shad are quite scarce (Baglinière, 2000). Thus a survey of the migration and population density of the species along the coast and lower course of rivers is needed.



Fig. 1. The study area with indications of main basins cited in the text; a) Lake Orta, b) Lake Maggiore, c) Lake Como, d) Lake Lugano, e) Lake Iseo, f) Lake Garda, g) River Po, h) Lake Bracciano, i) Lake Vico, l) River Tiber, m), Lake Omodeo, n) River Tirso, o) River Neretva, p) Lake Skadar, q) Lake Ohrid, r) River Evros, s) River Nestos, t) River Strymon, u) River Pinnios.

In this paper, I outline the status of *A. agone* in Italy and the western Balkans, where the species seems to be most frequent and most studied. The names of principal basins of the study area, discussed in the text, are reported in Fig. 1.

Survey methods

I examined the old and recent literature on the local or general status of the genus *Alosa* in Italy and the western Balkans. Unpublished reports were also consulted, especially those concerning northern Italy. Several technical papers deal with the life history or fisheries because the landlocked form of *Alosa* is intensively fished and has local commercial value in that area. Little-known publications from the western Balkans (Montenegro, Croatia, FYROM) were also consulted and some local fishermen were interviewed.

For complementary analyses, I have also included morphological data of several samples of *Alosa* housed in my Department: a) 8 fishes from the Neretva basin, Croatia, collected by M. Mrakovcic in May 1994; b) 3 fishes from Lake Skadar, Montenegro, collected by the late B. Knezevic in June 1975; c) 10 specimens from the Adriatic coast near Pescara, central Italy, collected by G. Amazzalossi in June 2000; d) 2 specimens from Lake Omodeo in Sardinia, collected by P. Massidda in June 1999. Gill raker counts and measurements were made according to Holcik (1989). The results are reported in Table 1.

Fluctuation and variation of the twaite shad in Italy and the western Balkans

Two ‘ecological forms’, sometimes regarded as subspecies, occur in fresh waters or seas of Italy and the western Balkans: the migratory form, known in the vernacular as ‘Cheppia’ or ‘Laccia’, and the landlocked form, called ‘Agone’. Both forms have been known since historical times. An interesting documentation of the history of these two forms is reported in the first extensive Italian ichthyological work published about four centuries ago (Salviani, 1554). According to this author, the distinction between the two forms was known since the ancient Greek and Roman periods. Salviani provided

Table 1. Mean measurements or range (expressed as thousandths of the Standard Length) and gill raker counts (standard deviation in parentheses) in two samples of the migratory form of twaite shad (Pescara and Neretva) and two variables lacustrine populations from Lakes Skadar and Omodeo.

Locality	n	Standard length (mm)	Head length	Head depth	Body depth	Least depth	Scales on ventral keel	Gill rakers	Dorsal fin rays	Anal fin rays
River Neretva	8	265–340	265(5)	227(5)	261(10)	90(4)	38(1)	35(2)	15(0)	20(1)
Lake Skadar	3	235–324	238–244	176–186	248–259	73–79	35–36	32–33	15	19–20
River Pescara	10	212–322	258(13)	209(9)	274(11)	89(4)	38 (1)	35(2)	15(0)	18(1)
Lake Omodeo	2	226–227	240–256	176–192	247–251	79–83	36–38	48–49	15–15	20–21

the first acceptable drawings of both forms. The marine migratory form was common in all Mediterranean drainage basins (Scotti, 1897), but it disappeared in dammed or blocked rivers. Today, few reproductive migratory populations remain in the Mediterranean (Baglinière, 2000), while the landlocked 'Agone' still forms substantial populations, especially in northern and central Italy.

### 1. Distribution and fluctuations of the migratory form

In Italy the migratory form is still quite common near the estuary and in the lower course of rivers. The shads usually enter the river mouth following the first spring flood, but the run stops just below the first dam where they remain until the end of the reproductive season, which is usually unsuccessful (Vitali *et al.*, 1983). In historical times, the migratory form was known to reach Milan in the Po River basin and, on the main course, the town of Casale about 400 km from the Po mouth (De Filippi, 1844; Pavesi, 1896). The Isola Serafini dam has now been abandoned and several fish ladders allow the 'Cheppia' to run upstream again (G. Gandolfi, pers. Comm.). In Veneto, it used to reach the lakes near Mantua, the Adige and other large rivers of central and north-eastern Italy (Pomini, 1937; Gridelli, 1935). In the upper Adriatic river basins the species now occurs mainly along coastal areas and river mouths (Loro *et al.*, 1994; Marconato *et al.*, 1986; Maio & Turin, 1999). In central Italy, upstream migration occurred in all water courses, even for more than 100 km in major rivers. In the Tiber River the migratory form was able to reach Orvieto (Paglia River) and Todi, two classic spawning sites for this species about 210 km from the river mouth (D'Ancona, 1927). Today, upstream migration is prevented by a dam near Rome.

In Italy the migratory form has never come into contact with an established population of the landlocked form and has never entered Lakes Maggiore (Grimaldi, 1997), Como, Iseo (Negri, 1993) and Garda (Malfer, 1922). In Sardinia, migratory populations on the Tirso River became landlocked in several artificial lakes on the river, *i. e.* Lakes Omodeo, Castel Doria, Del Posada, Villanovatulo (Cottiglia, 1963a, 1968). However, the twaite shad has apparently disappeared due to dry seasons in recent years (P. Massidda, pers. comm.).

In Croatia the shad occurs along the coasts, but apparently only enters the River Neretva (Vukovic, 1961; Mrakovcic *et al.*, 1995). Landlocked migratory populations are known to exist in several artificial lakes (M. Mrakovcic, pers. comm.).

In Montenegro, Albania and FYROM, it is distributed along the Adriatic coast and enters at least the Drin River to spawn. In the past, it could migrate into Lake Skadar through the River Bojana and running populations were probably able to reach Lake Ohrid and Lake Bacinska (Tocko & Jovanovic, 1959; Vukovic & Ivanovic, 1971; Maric & Kazic, 1990; Maric, 1995). The species appeared in catches from Lake Skadar until 1987. Following construction of a dam on the Bojana River (the emissary of Lake Skadar) in the Albanian part of the basin, there was a drastic reduction of euryhaline species such as mugilids, acipenserids and shads. The shad rapidly decreased and disappeared, at least as a species included in fishing statistics (Stein *et al.*, 1981; Maric & Kazic, 1990). At present, the migratory form seems to be very rare in the lake (D. Maric, pers. Comm.).

## 2. Distribution and fluctuations of the landlocked form "Agone"

*Italy*: major lakes of northern regions (Lakes Maggiore, Lugano, Como, Iseo, Mergozzo, Garda). Stocked in lakes of central Italy (Lakes Bracciano, Vico, Bolsena) (Brunelli, 1926) with specimens from Lake Como (Chiappi, 1933). It is still present in Lake Bracciano, but has disappeared from Lakes Vico (P. G. Bianco, pers. Observ.) and Bolsena (Taddei *et al.*, 1999) (Fig. 1).

*Croatia, Montenegro, FYROM, Albania*: apparently present only in Lake Skadar (Vukovic & Ivanovic, 1971; D. Maric, pers. comm.), where both landlocked and migratory forms spawn, but in different substrates and seasons (Rakaj & Crivelli, 2000). The species appeared in fishing statistics for Lake Skadar until 1987. After construction of the above-mentioned dam, the twaite shad rapidly decreased and at present the lake maintains only a small population of probably the landlocked form (Maric & Kazic, 1990; M. Maric, pers. comm.). Another population is known to live in Lake Ohrid, FYROM (Tocko & Jovanovic, 1959), but we have no recent information about the status of the shad in this lake.

## 3. Variability of general morphology and taxonomic implications

The main morphological distinction between the migratory and landlocked forms (Tor-tonese, 1970) is the shape of the body and the head: in the migratory form, the body is deeper and the head is longer. The number of gill rakers is quite variable, but the migratory form usually has 35–45, whereas the landlocked form has 50–60. However, there are two exceptions:

- 1) in the migratory form landlocked in Lake Omodeo in Sardinia, the number of gill rakers has increased and the body has become like that of the true landlocked form;
- 2) in Lake Skadar, true landlocked populations have a small number of gill rakers like the migratory form.

For the twaite shad, the number of gill rakers has a taxonomic value. Thus, several subspecies are reported for the Mediterranean area, sometimes with an overlap of distribution (Quignard & Douchement, 1991):

- *Alosa fallax lacustris*, reported in lakes of northern Italy, central Italy (where it was introduced) and Sardinia (where populations of the migratory form became landlocked following the construction of weirs);
- *Alosa fallax nilotica*, reported in eastern drainages of the Adriatic Sea, lakes of northern Italy, and Lakes Scutari and Ohrid in the western Balkans;
- *Alosa fallax rhodanensis*, reported in lakes of central Italy and Sardinia.

The taxonomy of Quignard & Douchement is difficult to follow since it is based on very variable and adaptive characters such as the number of gill rakers and the size of the head and body. Moreover, it is difficult to accept the coexistence of more than one subspecies in the same basin. Finally, a third taxon, *A. algeriensis*, is also reported for the island of Sardinia (Kottelat, 1997).

Counts of gill rakers are quite variable and differ from lake to lake. For instance, in Lake Garda the mean number of gill rakers (standard deviation in parentheses) in 249 fishes was 60 (4) (Novello & Oppi, 1985; Oppi & Novello, 1986), while in Lake Skadar,

the landlocked populations (40 fishes, with a slender body and short head) had 31–35 gill rakers (mean 33.4) (Ivanovic, 1973). The number of gill rakers in the Lake Skadar fishes corresponds to that of the migratory form, which should be the result of trophic habits since the landlocked form shows the same benthic habits as the migratory form (Ivanovic, 1973). This is probably due to the shallowness of Lake Skadar (max. depth about 9 m), which does not permit development of the large planktonic communities that usually live in deep lakes (Karaman & Beeton, 1981). This indicates a good ability of the shad to modify its trophic habits and its ‘gill raker filter’ in a few generations according to the local ecological conditions and food availability.

#### 4. Remarks on the biology and feeding habits

The two eco-phenotypes ‘Cheppia’ and ‘Agone’ have a different biology and feeding habits. When landlocked, running populations of ‘Cheppia’ tend to assume all the characters of the landlocked ‘Agone’. In contrast, there are no reported cases of ‘Agone’ becoming migratory.

##### a. Landlocked populations

*Italy*: sexual maturity is reached at age 2+ in males and 2+ or 3+ in females, at a total length of 19–24 cm. Most frequent age classes of mature adults: II, III, IV. Longevity: 5 or 6 years. The spawning season extends from May to July, with some cases of reproduction in August. Sex ratio about 50 %, with local or seasonal fluctuations. Maximum activity in June with local maxima in May or July. Maximum total length 35–38 cm, maximum weight 400–500 g (Malfer, 1922; Berg & Grimaldi, 1966; Oppi & Novello, 1986; Negri, 1993; Confortini, 1998). The resident form is mainly a plankton feeder. In populations of northern Italian lakes, the diet is composed mostly of Cladocera and Copepoda (crustaceans), but there is a seasonal variation of these components. Copepoda is the major component of the diet from November/December to March/April, while Cladocera is the main component from April/May to October (Oppi & Novello, 1985; Negri, 1993; Confortini, 1998).

*Montenegro*: in Lake Skadar, spawning occurs in spring. According to Vukovic (1961) and Rakaj & Crivelli (2000), both migratory and landlocked populations of twaite shad live in Lake Skadar, but they are spatially and reproductively isolated. The migratory and landlocked forms have the same feeding habits, which consist of benthic components. However, unlike the situation in Italy, both forms show the same range of gill rakers. Nevertheless, for other parameters, they show the same differences as between ‘Agone’ and ‘Cheppia’ (Table 2). The adults of the landlocked form are mostly aged 2+ and are bottom feeders. Food items in small and medium-sized specimens are mostly crustaceans, with a high percentage of Amphipoda and Isopoda. Larger specimens may feed on small benthic fishes such as gobiids, blennids, *etc.* (Ivanovic, 1973).

Table 2. Monthly spawning activities observed in populations of landlocked and migratory twaite shad from several lakes and river basins of the study area. Abbreviations used: + lowest density, ++++ highest density; RU, running upstream; RD, running downstream.

Landlocked form of <i>Alosa agone</i> 'Agone'							Main References
Lakes	March	April	May	June	July	August	
Garda			+	++++	+++	+	Oppi & Novello 1986
Maggiore			++	++++	++		Berg & Grimaldi, 1966
Como			+	++++	++		Negri, 1993
Skadar		++	++++	++			Ivanovic, 1973
Migratory form of <i>Alosa agone</i> 'Cheppia'							Main References
Rivers	March	April	May	June	July	August	
Po	RU ++	RU ++	++++	++ RD	Run down		Gandolfi <i>et al.</i> , 1985
Tiber	RU ++	RU+++	++++	+++ RD	+ RD		D'ancona, 1927
Tirso	RU +	RU ++	++++	++ RD	RD	RD	Cottiglia, 1963a
Skadar (past)	RU++	RU++	++++	++	RD		Vukovic, 1961
Rhône	RU (males)	RU++ (females)	++++	+++ RD	RD	RD	Rameye <i>et al.</i> , 1976

b. Migratory form

*Italy*: sexual maturity is reached at age 3+ or 4+ in males and 4+ or 5+ in females, at a total length of 22-36 cm. Most frequent age classes of adults: IV, V, VI, VII. The sex ratio is similar for both sexes, but males reach the spawning grounds about 2–3 weeks before females and then leave before the females. Thus, the sex ratio seems to favour one or the other sex depending on the time of observation. Females are multispawners and each of them can reproduce up to 4–5 times in the same season. Maximum length about 60 cm. Maximum weight 1600-1800 gr. Maximum age 8–9 years (D’Ancona, 1927; Gandolfi *et al.*, 1985; Serventi *et al.*, 1991). The migratory form is a bottom feeder, the food items being molluscs and crustaceans. Larger specimens may feed on small benthic fishes such as gobiids and blennids. Table 2 shows a comparison of the spawning seasons of the two forms, with the months of major spawning activities.

c. The case of ‘Cheppia’ of Lake Omodeo

Running populations of twaite shad in the Tirso River were landlocked after creation of the artificial Lake Omodeo in 1922. As a result, the biology and ecology of the populations in the lake changed, becoming very similar to those of ‘Agone’ of northern Italian

Table 3. Characters discriminating between *Alosa agone* from the River Tirso and from Lake Omodeo in Sardinia, where it was trapped in 1922.

Character	Body	Head	Gill Rakers	Trophic habits	Total length
Tirso	Deep	Longer	46	Benthonic	Up to 45 cm
Omodeo	Slender	Shorter	50	Planktonic	Up to 28 cm

lakes. Table 3 summarises the distinction after 80 years of isolation between the migratory Tirso River form (Cottiglia, 1963b) and the derived populations landlocked in Lake Omodeo (Cottiglia, 1963a). Compared with the original value in Table 1, the number of gill rakers has apparently not varied from 1966 to 2000.

#### d. Fluctuations of populations according to fishing catches

The landlocked 'Agone' is subjected to intensive fishing in all major lakes of Italy and in Lake Skadar. In Lake Maggiore (Fig. 2), the species disappeared from fishing statistics before 1979 (Giussani, 1989), but the populations increased from 1982 to 1995. There are no data for catches after 1995 because commercial fishing in this lake was suspended in 1996. In Lake Como, following a period of low density, the populations increased and from 1996 to 1999 the annual catches were 25–40 tons. Fishing of 'Agone' has been very important in Lake Garda (Fig. 4): since 1982, with a catch below 100 tons/year, the production has increased to 150–200 tons/year. In the Montenegrin part of Lake Skadar, the shad was one of the most important commercial species until 1963. However, production declined drastically after construction of a dam on the Bojana River (Fig. 4).

## Taxonomy

The number of gill rakers is usually adopted for taxonomic purposes in shads. The distinction between the allis and the twaite shad is quite evident because there is no overlap of gill raker counts (30–60 in *Alosa agone* versus 90–120 in *A. alosa*) and this distinc-

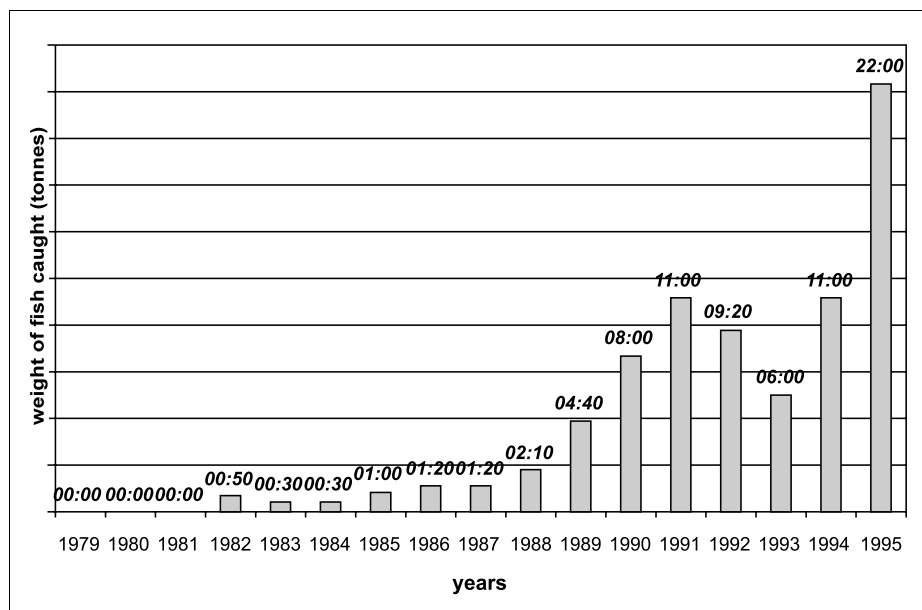


Fig. 2. Yearly catches of 'Agone' in Lake Maggiore (Grimaldi, 1997). Top numbers are tonnes.



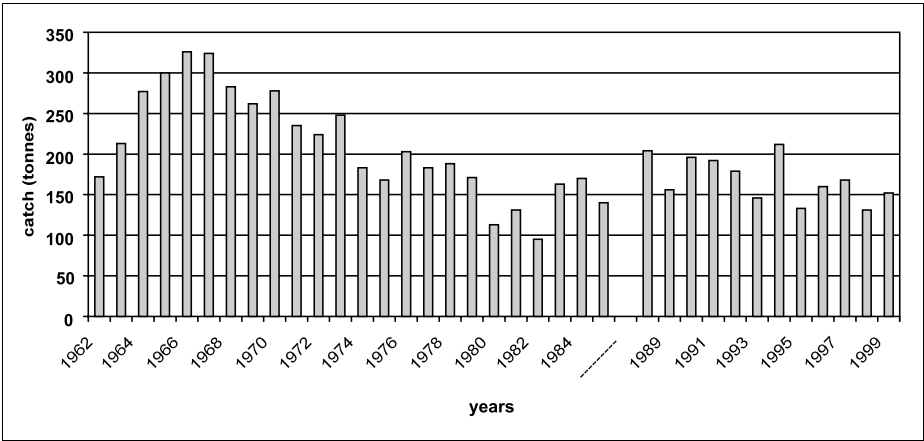


Fig. 3. Yearly catches of ‘Agone’ in Lake Garda (Oppi & Novello, 1986; Confortini, 1998 & pers. Comm.).

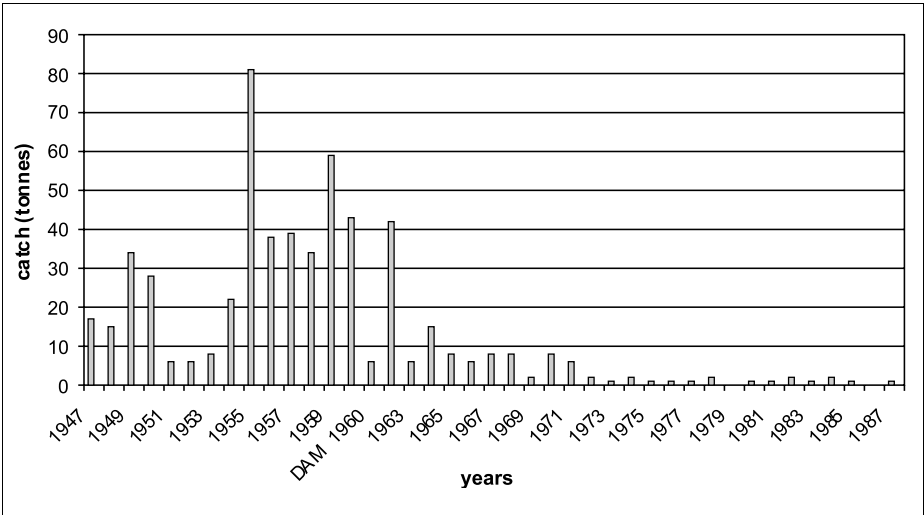


Fig. 4. Yearly catches of *Alosa* in Lake Skadar (Stein *et al.*, 1981; Maric & Kazic, 1990).

tion is also supported by genetic analyses (Boisenau *et al.*, 1992; Alexandrino, 1996; Alexandrino & Castro Linhares, 2000). However, the taxa belonging to the ‘fallax’ or ‘agone’ complex are difficult to separate. Several taxa have been described in the past, mostly according to body shape and number of gill rakers. For instance, Barbieri (1907) described three taxa for Lakes Maggiore, Como and Garda, respectively, mainly according to the different range of gill raker numbers. Later, Regan (1916) described another three taxa, again according to different numbers of gill rakers. Gill rakers, however, are also subject to ontogenetic variations and the number tends to increase with size, as observed in the Tirso River for the migratory form (Cottiglia, 1963b) and in Lake Como (Fig. 5).

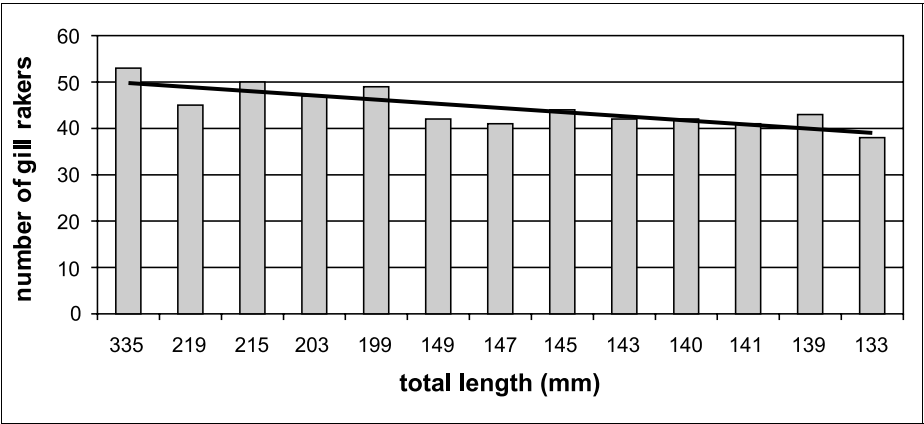


Fig. 5. Number of gill rakers in ‘Agone’ from Lake Como in fish of decreasing size and the regression line (Barbieri, 1907).

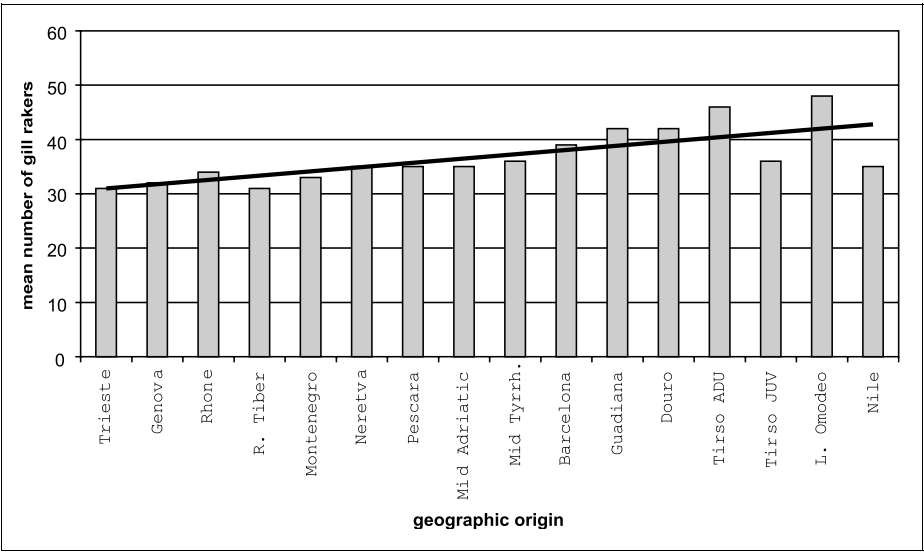


Fig. 6. Mean number of gill rakers in populations of migratory *Alosa agone* from north to south and the regression line (Barbieri, 1907; D’Ancona, 1927; Cottiglia b, 1963; Ferrero, 1951; Ivanovic, 1973; Rameye *et al.*, 1976; Costa Eiras, 1980; present study).

Fig. 6 illustrates the north-south geographical variation of the mean number of gill rakers in central Mediterranean populations. The mean increases from about 32 to about 48. According to this cline, only one taxon should be considered for the ‘Cheppia’ migratory form in the Mediterranean area.

The number of gill rakers is also quite variable in landlocked populations, varying from 32-34 in Lake Skadar to about 60 in Lake Garda, with intermediate values in

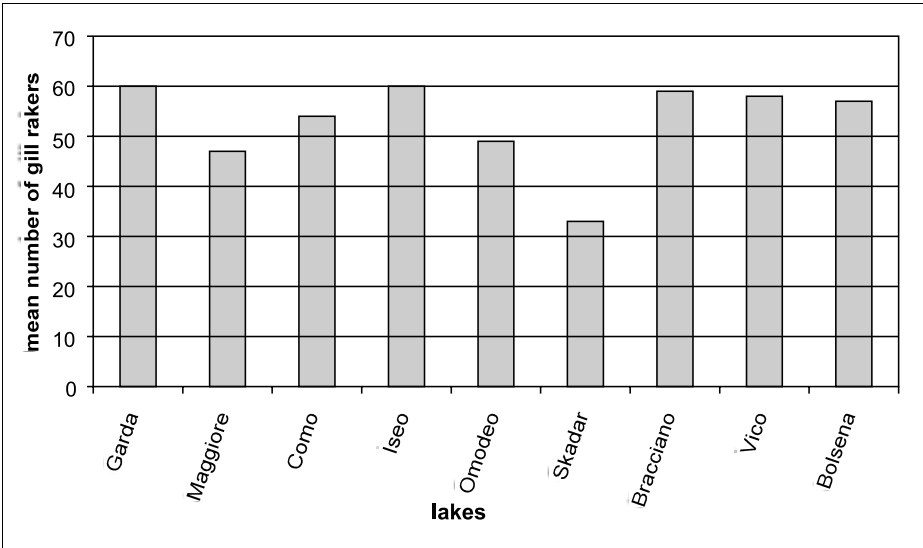


Fig. 7. Mean number of gill rakers in landlocked populations of *Alosa agone* from Italy and Montenegro (Barbieri, 1907; Cottiglia, 1963a; Ivanovic, 1973; Bianco, pers. Observ.).

populations of other lakes (Fig. 7). Table 4 summarises the main differences between the landlocked and migratory forms of twaite shad in Italy.

The case of landlocked shads in Lake Skadar and Lake Omodeo (Table 1 and Table 3) shows that the species is variable and able to modify its ecology, biology, feeding and morphology as a result of adaptation to freshwater or marine environments. Therefore, in the Mediterranean area we can recognise only one very variable taxon, which should be referred to *Alosa agone* (Scopoli, 1786) according to its first description for Lake Lugano in Switzerland (Kottelat, 1997). Table 5 reports the synonyms of this species. A question mark on *Alosa fallax* (Lacépède, 1803) indicates that this taxon, described for the western Atlantic part of Europe (Seine River in France) (Kottelat, 1997), is probably distinct from *A. agone*. According to Le Corre *et al.* (2000), there is an appreciable genetic divergence between *A. agone* from the Rhône basin (Mediterranean) and *A. fallax* from the Atlantic coasts.

Table 4. Characters discriminating between landlocked ‘Agone’ and migratory ‘Cheppia’ from Italian freshwaters and seas.

Character	Body	Head	Gill Rakers (range)	Feeding habits	Total length (cm)	Spawning season	Longevity (years)	Age of first maturity	
								Males	Females
Agone	Slender	Shorter	46–60	Planktonic	Up to 58–60	April–June	Up to 5–6	2+, 3+	3+, 4+
Cheppia	Deep	Longer	28–36	Benthonic	Up to 28–30	May–July	Up to 8–9	3+, 4+	4+, 5+

Table 5. Synonyms of *Alosa agone* (Scopoli, 1786) for nominal taxa described for the Mediterranean drainage area (modified from Kottelat, 1997).

<i>Alosa agone</i> (Scopoli, 1786)	
Synonym	Author (Type locality)
<i>Cyprinus agone</i>	Scopoli, 1786 (L. Lugano)
*? <i>Clupea fallax</i> (Atlantic)	La Cepède 1803 (R. Seine)
*? <i>Clupea rufa</i> (Atlantic)	La Cepède 1803 (R. Seine)
<i>Clupea nilotica</i>	Geoffroy-Saint-Hilaire, 1808 (Nile)
<i>Clupea finta</i>	Cuvier, 1829 (Type Loc. not designated)
<i>Clupea sardinella</i>	Vallot, 1837 (Lakes North Italy)
<i>Alosa finta lacustris</i>	Fatio, 1890 (L. Lugano)
<i>Alosa lacustris ceresio-verbana</i>	Barbieri, 1907 (L. Maggiore & Lugano)
<i>Alosa lacustris lariana</i>	Barbieri, 1907 (L. Como)
<i>Alosa lacustris benacensis</i>	Barbieri, 1907 (L. Garda)
<i>Alosa finta gracilis</i>	Regan, 1916 (L. Garda)
<i>Alosa finta algeriensis</i>	Regan, 1916 (Algeria & Morocco)
<i>Alosa finta africana</i>	Regan, 1916 (Algeria & Morocco)
<i>Alosa finta rhodanensis</i>	Roule, 1924 (R. Rhône)

## Conservation

In Italy the landlocked form of twaite shad should be considered as vulnerable, according to IUCN (2000) categories, and the migratory form as endangered (Bianco, 1998). The situation in Croatia, Montenegro and Albania is similar (Mrakovcic *et al.*, 1995; Maric, 1995).

## Conclusions

The twaite shad is a highly polymorphic and adaptable species, able to modify its ecology, biology, feeding and morphology as result of adaptation to freshwater or marine environments. Only one taxon should be identified in the Mediterranean area, *Alosa agone* (Scopoli, 1786). The species undergoes local fluctuations depending on river flows, water quality, competition with other species and food availability. A pan Mediterranean-Atlantic genetic analysis of populations of nominal taxa or local forms of the genus *Alosa*, especially those inhabiting lakes in Italy and Montenegro, is needed in order to clarify the taxonomic position and the conservation status of Mediterranean and Atlantic populations.

## Acknowledgements

Dr. Draco Maric from the University of Montenegro, Dr. Milorad Mrakovcic from the University of Zagreb (Croatia) for information on *Alosa* from their countries, and Dr. Peter Christie for the English revision of the text.

## References

- Alexandrino, P., 1996: Genetic and morphological differentiation among some Portuguese populations of allis shad, *Alosa alosa*, and twaite shad *Alosa fallax*. Publ. Espec. Inst. Esp. Oceanogr., 21: 15–24.
- Alexandrino, P. & F. D. Castro Linhares, 2000: Species differentiation, population structure and hybridisation in allis shad (*Alosa alosa*), and twaite shad (*Alosa fallax*): a genetic analysis based on protein loci. 1st Conference on European shads, May 2000, Programme & Abstracts, Pessac, France, p. 1.
- Baglinière, J. C., 2000: Le genre *Alosa* sp. In: J. C. Baglinière (Ed.), Les aloses (*Alosa alosa* et *Alosa fallax* spp.). CEMAGREF, INRA, Paris: 3–30.
- Barbieri, C., 1907: Le alose del Mediterraneo e gli agoni dei laghi lombardi. Studio preliminare. Rivista mensile di pesca, 9: 1–32.
- Berg, A. & E. Grimaldi, 1966: Biologia dell' agone (*Alosa ficta lacustris*) del Lago Maggiore. Mem. Ist. Ital. Idrobiol., 20: 42–83.
- Bianco, P. G., 1998: Freshwater fish transfers in Italy: history, local modification of fish composition, and a prediction on the future of native populations. In: J. Cowx (Ed.), Stocking and Introductions of Fishes. Fishing News Book, Blackwell Science, Oxford: 165–197.
- Bobori, D. C., M. T. Koutrakis & P. S. Economidis, 2000: Shad species in Greek waters – A historical overview and recent status. 1st Conference on European shads, May 2000, Programme & Abstracts, Pessac, France, p. 8.
- Boisneau, P., C. Mennesson-Bisneau & R. Guyomard, 1992: Electrophoretic identity between allis shad, *Alosa alosa*, and twaite shad, *Alosa agone*. J. Fish. Biol., 40: 731–738.
- Brunelli, G., 1926: Introduzione dell' agone, del pesce persico e della pianuzza nelle acque dell' Italia centrale. Boll. Pesca Piscic. Idrobiol., 2: 3–5.
- Chiappi, T., 1933: Note su alcuni stadi di sviluppo dell' Agone introdotto nei laghi laziali e della Cheppia del Tevere. Boll. Pesca Piscic. Idrobiol., 9: 121–132.
- Confortini, I., 1998: Evoluzione della comunità ittica del lago di Garda. Situazione attuale e passata. ATTI 6° Conv. AIAD. Regione Liguria, Provincia della Spezia, 77–86.
- Costa Eiras Da, J., 1980: *Alosa fallax* from North and South of Portugal: study of its numerical characters. Publ. Inst. Zool. 'Augusto Nobre', n 155, Porto: 15 p.
- Cottiglia, M., 1963a: Studi sull'ittiofauna dulciacquicola della Sardegna. I - L'alosa migratrice del Tirso. Boll. Pesca Piscic. Idrobiol., 18: 15–38.
- Cottiglia, M., 1963b: Studi sull'ittiofauna dulciacquicola della della Sardegna. I – Gli agoni del lago Omodeo. Boll. Pesca Piscic. Idrobiol., 18: 125–142.
- Cottiglia, M., 1968: La distribuzione dell'ittiofauna dulciacquicola in Sardegna. Riv. Idrobiol., 7: 63–116.
- D'Ancona, U., 1927: Notizie sulla biologia dell' *Alosa finta* del bacino del Tevere. Ministero de Marina, Direccion General de Pesca. Notas y Resúmenes. Serie 2, n. 19, Madrid: 19 pp.
- Elvira, B., 1995: Conservation status of endemic freshwater fish in Spain. Biol. Conserv., 72: 129–136.
- Ferrero, L., 1951: Studio comparativo sulle cheppie e gli agoni delle acque interne d'Italia. Boll. Pesca Piscic. Idrobiol., 27: 108–133.
- Filippi De, F., 1844: Pesci finora osservati in Lombardia. Notizie Nat. Civ. su la Lombardia, I: 389–406.
- Gandolfi, G., S. Zerunian, P. Torricelli & A. Marconato, 1991: I pesci delle acque interne Italiane. Ministero dell' Ambiente, Unione Zoologica Italiana. Istituto Poligrafico e Zecca dello Stato, Roma: 616 pp.
- Gandolfi, G., E. Ioannilli & R. Vitali, 1985: Caratteristiche biologiche delle comunità ittiche, studi sulle migrazioni e aspetti quantitativi delle attività aleutiche nel delto del Po. Nova Thalassia, 7: 281–309.
- Giussani, G., 1989: Lago Maggiore fish community evolution. Mem. Ist. Ital. Idrobiol., 46: 125–135.
- Grimaldi, E., 1997: Ricerche sulle acque Italo Svizzere nel quadriennio 1992–1995. Commissione Italo Svizzera per la pesca, 2: 1–83.
- Gridelli, E., 1935: I pesci d'acqua dolce della Venezia Giulia. Udine: 68 pp.
- Holicik, J., (Ed.) 1989: The freshwater fishes of Europe. I, General Introduction to fishes. AULA-Verlag, Wiesbaden: 469 pp.
- Ivanovic, B. M., 1973: Ichthyofauna of Skadar Lake. Titograd: 146 pp.
- Karaman, G. S. & A. M. Beeton (Eds.), 1981: The Biota and Limnology of Lake Skadar. Montenegro, Titograd: 468 pp.
- Kottelat, M., 1997: European freshwater fishes. Biologia, 52 ( Suppl. 5): 1–271.
- Le Corre, M., D. Linhares, F. Castro & P. Alexandrino, 2000: Caracterisation génétique de l'alose du Rhône (*Alosa fallax rhodanensis* Roule 1924). 1st Conference on European shads, May 2000, Abstracts: 27.
- Loro, R., M. Zanetti, & P. Turin, 1994: Carta ittica. Provincia di Treviso, Ass Caccia Pesca Ecologia. Treviso: 184 pp.
- Maf, 1931: La pesca nei mari e nelle acque interne d'Italia. Ministero Agricoltura e Foreste. Istituto Poligrafico dello stato. Volume secondo, Roma,
- Maio, G. & P. Turin, 1999: Carta ittica della Provincia di Rovigo. Provincia di Rovigo, Assessorato Caccia Pesca, 278 pp.
- Malfer, F., 1922: Sui clupeidi del Benaco. Atti Accad Agric. Sc. Lettere, 24: 151–195.

- Marconato, A., S. Salviati, G. Maio & E. Marconato, 1986: La distribuzione dell'ittiofauna nella provincia di Vicenza. Provincia di Vicenza, Assessorato Pesca, Vicenza; 149 pp.
- Maric, D., 1995: Endemic fish of Montenegro. Biol. Conserv., 72: 187–194.
- Maric, D. & D. Kazic 1990: Qualitative and quantitative composition of ichthyofauna of Skadar lake sublacustrine springs in winter period from 1967 to 1987. Glas. Republ. Zavoda Zast. Prirodne-Prirodnjackog Muzeja Titograd, 23: 85–96.
- Mrakovcic, M., S. Misetic & M. Povz, 1995: Status of freshwater fish in Croatian Adriatic river systems. Biol. Conserv., Biol. Conserv., 72: 179–185.
- Negri, A., 1993: La biologia dell' agone del Lago di Como. Prima parte. Amministrazione Provinciale, Assessorato Caccia Pesca, Como; 99 pp.
- Novello, R. & E. Oppi, 1985: Biologia e pesca dell' agone nel Lago di Garda. Il Garda, l'ambiente, l'uomo: prima miscellanea di studi. Centro studi per il territorio benacense. La Grafica di Lavagno, Verona; pp. 21–34.
- Oppi, E. & R. Novello, 1986: Ulteriori osservazioni sulla biologia e pesca dell' agone (*Alosa fallax lacustris*) nel Lago di Garda. Federazione Italiana Pesca Sportiva, Verona; 18 pp.
- Pavesi, P., 1896: La distribuzione dei pesci in Lombardia. Soc. Lomb. Pesca Acicol., Pavia, 10: 1–40.
- Pomini, F. P., 1937: Osservazioni sull' ittiofauna del Veneto e indagini riguardanti la pesca. Boll. Pesca Piscic. Idrobiol., 13: 262–312.
- Quignard, J.-P. & C. Douchement, 1991: *Alosa fallax* (La Cepède, 1803). In: H. Hoestlandt (Ed), The freshwater fishes of Europe. Vol. II. Clupeidae, Anguillidae, AULA-Verlag, Wiesbaden: 211–296.
- Rakaj, N. & A. Crivelli, 2000: Occurrence of agone, *Alosa lacustris*, in lake Shkodora, Albania, in sympatry with twaite shad. 1st Conference on European shads, May 2000, Programme & Abstracts, Pessac, France: 41.
- Rameye, L., A. Kiener, C.-P. Spillmann & J. Biousse, 1976: Aspects de la biologie de l'Alose du Rhône. Peche et difficultes croissantes de ses migrations. Bull. Fr. Piscic., 263: 50–76.
- Regan, C. T., 1916: The British fish of the sub-family Clupeoninae and related species in other seas. Ann. Mag. Hist., 18: 1–19.
- Salviani, I., 1554: *Aquatilium Animalium Historiae*. Roma; 256 pp.
- Scotti, L., 1897: La distribuzione dei pesci d'acqua dolce in Italia. Giorn. Ital. Pesca Acqicolt., 11: 170–179.
- Serventi, M., R. Vitali, & G. Gandolfi, 1991: Biologia e biometria dei riproduttori di Alosa, *Alosa fallax*, in migrazione nel delta del Po. Riv. Idrobiol., 29(1990): 469–475.
- Stein, R. A., J. O. Mecom & B. Ivanovic, 1981: Commercial exploitation of fish stocks in Lake Skadar, 1947–1976. In: G. S. Karaman & A.M. Beeton (Eds.), The Biota and Limnology of Lake Skadar. Montenegro, Titograd: 343–354.
- Taddei, A., E. Calvario, S. Sarrocco & A. Pietromarchi, 1999: Indagine faunistica sui pesci del bacino idrografico del Lago di Bolsena (Italia centrale). Quaderni ETP, 28: 203–208.
- Tocko, M. & R. Jovanovic, 1959: *Alosa fallax nilotica* in Lake Ohrid. Zbornikna rabotite, Ohrid, 7: 1–12.
- Tortonese, E., 1970: Osteichthyes, pesci ossei. Fauna d'Italia, XI, Calderini, Bologna, 565 p.
- Vitali, R., M. Pesaro & G. Gandolfi, 1983: La migrazione dell'alosa *Alosa fallax nilotica* attraverso il delta del Po. Atti 5° Congr Associazione Italiana di Oceanologia e Limnologia, pp. 727–736.
- Vukovic, T., 1961: Populations of twaite shad *Alosa fallax nilotica* from River Neretva and Lake Skadar. Godisnjak Biol. Inst. Univer U Sarajevu, 15:2634.
- Vukovic, T. & B. Ivanovic, 1971: Freshwater fishes of Jugoslavia. Zemalski Musej Bosne i Hercegovine, Sarajevo; 263pp.