Redescription of *Coregonus bavaricus* Hofer, 1909 from Lake Ammersee, Bavaria (Salmoniformes: Coregonidae)

by

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ABSTRACT. - *Coregonus bavaricus* is redescribed based on literature data and three specimens from Lake Ammersee in Germany caught in 1951 (2) and 2003 (1). It is distinguished from other species of *Coregonus* in prealpine lakes by: 18-30 gill rakers; short head; pectorals, when folded forward, reaching at most to corner of mouth, pectorals 17-19% SL; spawning in June-July. This species is endemic to Lake Ammersee, and, apparently, at the very border of extinction today.

RÉSUMÉ. - Redescription de *Coregonus bavaricus* Hofer, 1909 (Salmoniformes : Coregonidae) du lac Ammersee, Bavière.

Coregonus bavaricus est redécrit à partir des données de la littérature, de deux spécimens collectés en 1951 dans le lac Ammersee en Allemagne et d'un spécimen collecté en 2003. Il se distingue des autres corégones des lacs préalpins par le nombre de branchiospines (18-30), une petite tête, des pectorales atteignant à peine la commissure des lèvres quand elles sont rabattues en avant et représentant 17 à 19% de la longueur standard, et d'après la littérature, une fraie en juin-juillet. Cette espèce endémique du lac Ammersee semble désormais pratiquement éteinte.

Key words. - Coregonidae - *Coregonus bavaricus* - Germany - Lake Ammersee - Endemic species.

Modern European concepts of nature conservation (Fauna-Flora-Habitat directives, Natura 2000 program) and IUCN Guidelines highlight the responsibility of any government, including Germany, to study and conserve endemic and endangered species of plants and animals. The Fauna-Flora-Habitat directive is in the focus of this problem covering all coregonid fishes. In Germany, most coregonid species are restricted to lakes and are therefore very sensitive to changes in the lake ecosystem. Unfortunately, the systematics of European coregonids is far from settled (see Kottelat, 1997). About most species, we have only few informations. Therefore, we are unable to answer basic questions addressed by nature conservation, which species of our native coregonids still survive or went extinct due to several reasons. If native coregonids are replaced by stocked or have hybridised with introduced species, this is clearly a loss of biodiversity (Nehring, 2000) and against the convention of biodiversity ratified by the German government (Bundesumweltministerium, 1998). Therefore, there is an urgent need of informations for nature conservation and modern fisheries management. To answer this question, the only way is to compare old descriptions and historic specimens with actual material from the lakes.

In prealpine lakes, there are some coregonids, which are locally called "Kilch", a name generally applied to small growing species, with low number of gill rakers usually caught in deep waters. Two of these species occur in lakes of the Upper River Rhine basin (Konstanz: *C. gutturosus*; Thun: *C. alpinus*) and *C. bavaricus* is known from Lake Ammersee in the upper River Danube basin. The existence of a Kilch in Lake Ammersee was already known to von Siebold (1863). Hofer (in Vogt and Hofer, 1909) described and named the Ammersee-Kilch as *Coregonus acronicus* Rapp varietas *bavarica*. Wagler (1933) examined the Ammersee-Kilch and give some data on its morphology and biology. Wagler's data were as well analysed by Steinmann (1950) and Dottrens (1959).

No later records are available on this species. Applying the phylogenetic species concept (see Cracraft, 1989; Mayden, 2002), Kottelat (1997) formally revalidated the Kilch from Lake Ammersee as *Coregonus bavaricus* based on given literature data.

Recently, two specimens of *C. bavaricus* were rediscovered in ZSM (ZSM 4260, 4927), belonging to Wagler's collection, which was almost completely destroyed during the Second World War. The intensive attempts to find *C. bavaricus* in the lake during more than two years (2002-2004) revealed one specimen only (ZSM 30462). However, these three specimens are everything what is actually available from this species. The three specimens and the descriptions by Vogt and Hofer (1909) and Wagler (1941) allow to compare one actual specimen with historic specimens and descriptions. The very low number of specimens examined might seem to disqualify this attempt.

Vogt and Hofer (1909) still stated, that the Ammersee-Kilch was an important commercial species. Wagler (1933)

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already noted, that fishermen at Lake Ammersee consider *C. bavaricus* as strongly declining and very rare. He mentioned overfishing by taking too small individuals as one reason for the rarity of this species. He also reported, that local fishermen blamed the regulation of the inflowing River Ammer to have changed the conditions negatively for *C. bavaricus*. Lake Ammersee was heavily eutrophicated after the 1950th. However, since the construction of a "ring-canal" draining local wastewaters out of the lakes basin in 1971, lakes water quality increased. Maybe the population of *C. bavaricus* has stabilised on a very low level, because local fishermen remember the kilch well, but considering this species as very rare today.

MATERIAL AND METHODS

Measurements and counts follow those of Schulz and Freyhof (2003). Abbreviations used denote the following morphometric characters and institutions: SL, standard length; HL, dorsal head length; ZSM, Zoologische Staatssammlung, München; ZMB, Museum für Naturkunde der Humboldt-Universität, Berlin.

Specimens examined (all from Germany)

Coregonus bavaricus. - ZSM 4260, 173.0 mm SL, Bavaria, Lake Ammersee at Diessen, 14 Dec. 1951, P. Ernst. - ZSM 4927, 192.3 mm SL, Bavaria, Lake Ammersee at Diessen, Dec. 1951, P. Ernst. - ZSM 30462, 241.0 mm SL, Bavaria, Lake Ammersee between Utting and Schoondorf, 2003, W. Ernst. *Coregonus gutturosus*. - ZMB 3768, syntypes of *C. acronius*, 2 ex., 168, 183 mm SL, Baden-Württemberg, Lake Konstanz, J. Müller, 1864. *Coregonus renke*. - ZSM 936, 1 ex. 163 mm SL, Bavaria, Lake Ammersee at Diessen, Backenhofer, Jul. 1948. - ZSM 3463, 1 ex. 229 mm SL, Bavaria, Lake Ammersee, E. Wagler, 9 Aug. 1944. - ZSM 30463, 1 ex., 210.0 mm SL, Bavaria, Lake Ammersee between Utting and Schoondorf, 2003, W. Ernst.

COREGONUS BAVARICUS HOFER, 1909

(Figs 1-2)

Coregonus acronicus Rapp, varietas *bavarica* Hofer (1909)

Diagnosis

Coregonus bavaricus is distinguished from other species of *Coregonus* in the Danube drainage by the following combination of characters: 18-28 (usually 21-24) gill rakers; pectoral short, when folded forwards reaching at most to corner of mouth, 17-19% SL; head small 21-22% SL, dorsal HL 16-17% SL; dorsal fin short 17-19 SL; pelvic fin short 17-19% SL; angle of anterior snout margin about 90° with horizontal body axis.

Description

See figures 1-2 for general appearance and table I for morphometric data of the three specimens examined. Small, elongated and moderately compressed species. Mouth subterminal, with maxilla reaching to anterior eye margin. Snout blunt. Lower jaw slightly projecting beyond maxilla articulation, mandible reaching backwards to centre of eye. Angle of anterior snout margin about 90° with horizontal body axis. Eye large, 0.9-1.4 times in interorbital width. Caudal peduncle 1.8-2.1 times longer than deep. Dorsal-fin margin slightly concave, pelvic-fin origin below branched dorsal-fin ray 4. In upper branch of first gill arch 7; 7; 11 gill rakers, in lower branch 12; 14; 19. Length of last gill raker in upper branch of first gill arch 60-72% of opposite inner gill filament. Gill raker at corner between upper and lower branch of first gill arch with 12-16 lateral spines, spines present on both sides from base to tip. Size up to 241 mm SL.

Dorsal fin with 8-$9^{1/2}$ branched rays. Caudal fin forked, with 9+8 branched rays. Anal fin with $11^{1/2}$ branched rays. Pectoral fin with 10-12 rays, reaching 47-63% of distance to pelvic-fin origin. Pelvic fin with 11-12 rays. Axillary pelvic lobe present. Lateral line complete, reaching caudal-fin base, perforating 76-79 scales on body and 3-4 on caudal-fin base. Predorsal scales 30-33, 8 scale rows between lateral line and pelvic-fin origin rows, 9 scale rows between lateral line and dorsal-fin origin.

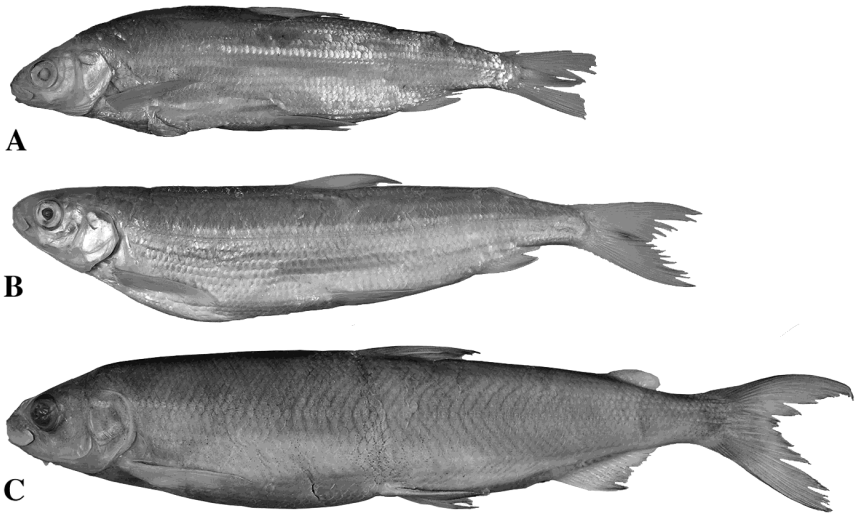

Figure 1. - *Coregonus bavaricus*. **A**: ZSM 4260, 173.0 mm SL; **B**: ZSM 4927, 192.3 mm SL; **C**: ZSM 30462, 241.0 mm SL. Germany: Lake Ammersee.

Sexual dimorphism

None observed.

Coloration

Body and fins silvery yellow in ethanol preservative. All fins, especially pelvic fin with pale grey flush in the specimen recently caught.

Notes on biology

All data are based on Vogt and Hofer (1909). The spawning of *C. bavaricus* peak between the 15th June and 15th July. Some females with ripe gonads are reported some weeks earlier and later. *Coregonus bavaricus* spawns on the lake bottom in 40-50 m depth all over the lake. No special spawning aggregations were reported. It was usually caught at about 60 m depth, may also be found down to 80. In summer it was reported from 30-40 m depth, but never in more shallow water. Mature females weight between 60-80 g and 80-90 g. It was caught with special nets, only about 70 cm height, which were dredged over the lake bottom. Biological data should be updated, what seems to be difficult considering the rarity of this species.

Distribution

Only known from Lake Ammersee, a 47 km² mesotrophic lake at 533 m (altitude) (maximum depth 81 m).

Remarks

Coregonus bavaricus is distinguished from sympatric winter-spawning *C. renke* (Paula Schrank, 1783) by: 18-30 gill rakers *vs* 33-38 in *C. renke* reported by Vogt and Hofer (1909); snout blunt (*vs* pointed); angle of anterior snout margin about 90° with horizontal body axis (*vs* about 75°). The three specimens of *C. renke* personally examined had 34, 35, 36 gill rakers. Small, deepwater coregonids from lakes in Danube basin are known from Lake Attersee: *C. austriacus* Vogt, 1909 and Lake Traunsee: *C. danneri* Vogt, 1908, both usually with 33-36, rarely down to 30 or up to 42 gill rakers (*vs* 18-30 in *C. bavaricus*). *C. austriacus* spawn in late December and *C. danneri* in mid-October to early-March (*vs* spawning peak between the 15th June and 15th July in *C. bavaricus*). *C. atterensis* Kottelat, 1997 (Lakes Attersee and Mondsee), *C. hoferi* Berg, 1932 (Lake Chiemsee) and *C. renke* (Lake Starnberger See) are other native species from the Upper Danube basin. All of them spawn in winter between December and March and therefore, are unlikely to be conspecific with *C. bavaricus*. In fact in all these species, there is an urgent need to compare actual and historic specimens if available.

From lakes in the River Rhine basin, summer spawning coregonids are reported from Lake Konstanz as Kilch *C. gutturosus* (Gmelin, 1818), Lake Thun as Kropfer *C. alpinus* Fatio, 1885 and from Lake Vierwaldstättersee as Edelfisch

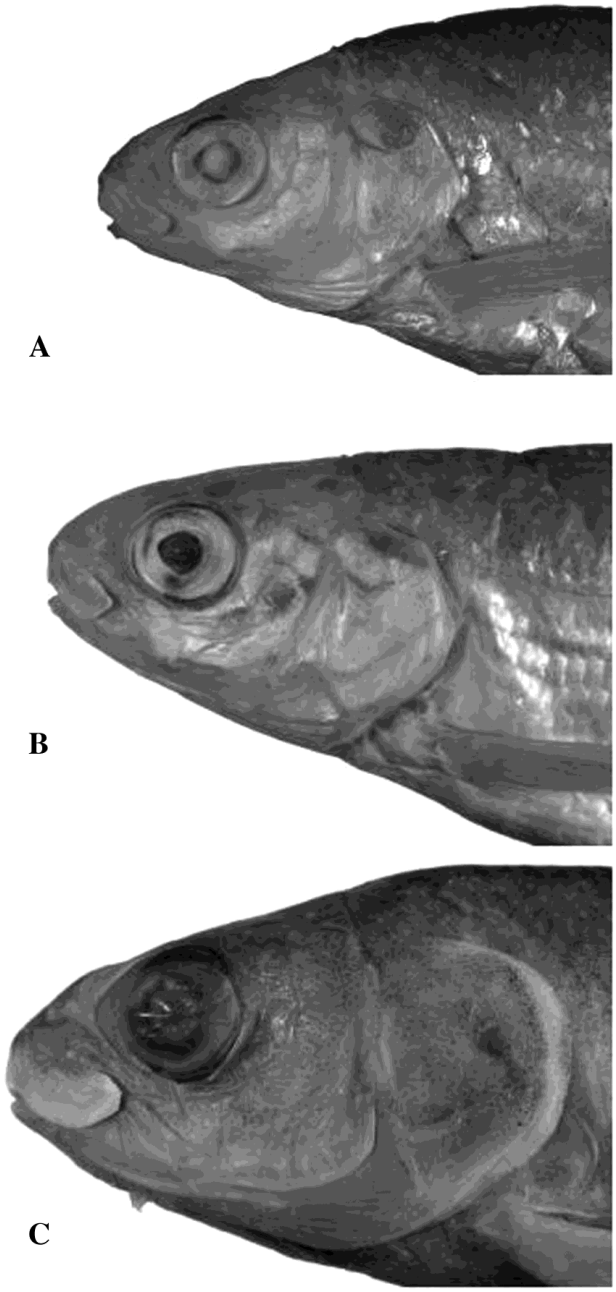

Figure 2. - Lateral view of head of *Coregonus bavaricus*. **A**: ZSM 4260, 173.0 mm SL; **B**: ZSM 4927, 192.3 mm SL; **C**: ZSM 30462, 241.0 mm SL. Germany: Lake Ammersee. *[Vue latérale de la tête.]*

C. nobilis Haack, 1882 (Fatio, 1890; Birrer and Schweizer, 1935; Wagler, 1941, 1950; Steinmann, 1950; Rufli, 1978; Ruhlé and Kindle, 1992; Kottelat, 1997). Whereas *C. nobilis* is distinguished from *C. bavaricus* by 31-42 gill rakers (*vs* 18-30), *C. alpinus* and *C. gutturosus* share the low number of gill rakers with *C. bavaricus*. Both species were associated with *C. bavaricus* by Wagler (1933).

Table I. - Morphometric data of *Coregonus bavaricus* from Lake Ammersee. *[Données morphométriques de* Coregonus bavaricus *du lac Ammersee.]*

	ZSM 4260	ZSM 4927	ZSM 30462
SL (mm)	173.0	192.3	241.0
In percent of SL			
Dorsal head length	16.9	16.2	16.4
Lateral head length (HL)	22.4	21.4	22.4
Pre-dorsal length	49.0	48.4	51.0
Pre-pelvic length	51.9	56.2	55.7
Pre-anus length	75.0	78.2	77.2
Pre-anal length	76.3	79.6	79.5
Head depth at eye	10.5	10.3	10.9
Head depth at nape	15.6	14.9	15.3
Body depth at dorsal-fin origin	24.0	21.0	19.9
Body depth at adipose origin	13.3	12.4	12.2
Depth of caudal peduncle	6.8	6.7	6.8
Length of caudal peduncle	12.0	13.0	14.2
Head width at gill openings	8.5	8.4	8.4
Body width at dorsal-fin origin	11.8	9.5	10.0
Body width at anal origin	6.9	6.0	6.5
Length of dorsal-fin base	10.7	9.2	10.6
Length of dorsal fin	19.6	18.4	17.3
Length of upper caudal lobe		22.1	19.3
Length of middle caudal-fin ray	8.7	9.7	8.0
length of lower caudal lobe		22.9	20.9
Length of anal-fin base	9.4	9.6	12.5
Length of anal fin	12.3	10.9	10.5
Length of pelvic fin	17.8	16.1	14.4
Length of pectoral fin	19.6	18.0	17.1
In percent of HL			
Eye diameter	26.8	25.1	19.9
Eye depth	23.9	21.6	20.3
Interorbital width	24.9	27.9	26.9
Snout length	24.3	27.3	26.7
Maxillary length	25.1	24.8	24.7
Mandible length	38.0	39.1	39.7
Maxillary width	11.0	11.0	10.7
Length of pectoral fin	87.3	83.8	76.3

Coregonus alpinus was not examined for this study. According to the molecular data presented by Douglas *et al.* (1999) and Douglas and Brunner (2002), *C. alpinus* belong to the endemic species flock of Lakes Thun and Brienz and it is therefore very unlikely, that *C. alpinus* is identical or even related with *C. bavaricus.*

Coregonus gutturosus might belong to the endemic species flock of Lake Konstanz but it was not included in the study by Douglas *et al*. (1999) or Douglas and Brunner (2002) because this species went extinct at an unknown year between the 1960 and 1970. *Coregonus bavaricus* as well was not included in these molecular studies, because these did deal with Swiss coregonids. *Coregonus bavaricus* is distinguished from *C. gutturosus* by angle of anterior snout margin about 90° with horizontal body axis (*vs* about 75° in *C. gutturosus*); gill raker at corner between upper and lower branch of first gill arch with 12-16 lateral spines, spines present on both sides from base to tip (*vs* 3-9 spines on one side; pectoral short, when folded forwards reaching at most to corner of mouth (*vs* reaching beyond); peak spawning between mid-June and mid-July (*vs* September-October). Whereas Wagler (1933) did not find morphometric differences between *C. gutturosus* and *C. bavaricus*, our specimens had a small head, 21-22% SL (*vs* 23-24% in *C. guttur - osus*), dorsal HL 16-17% SL (*vs* 18); short dorsal fin, 17-19 (*vs* 21-23% SL) and short pectoral fin, 17-19% SL (*vs* 20). The short pectoral fin of *C. bavaricus* were already reported by Siebold (1863) and Vogt and Hofer (1909) and confirmed by the material examined.

Spring or early summer spawning is recorded from several species of the distantly related *C. albula* group (see Schultz and Freyhof, 2003), but in *C. bavaricus* the combination of a low number of gill rakers and the spawning season in early summer is unique in prealpine coregonids.

The very limited material does not really allow making final conclusions about the relationships of *C. bavaricus* with other prealpine Coregonid species. Douglas *et al.* (1999) and Douglas and Brunner (2002) presented data, which support the occurrence of endemic coregonid species flocks in Swiss lakes. It should be expected, that this scenario is also true for Danubian lakes. Therefore, different species of “Kilch” might not be related to each other and similar characters might be the result of parallel evolution. Most likely, each “Kilch” has evolved within a single lake or group of lakes. Therefore, *C. bavaricus* should be related to species in other lakes of the upper Danube basin.

Wagler (1933) considered the small size of *C. bavaricus* to be the effect of high fishing pressure, reporting, that most fish were taken before or after first spawning. Most specimens examined by Wagler (1933) weighted 48-64 g, maximum 80 g. However, Vogt and Hofer (1909) already reported the small size of this species. He found mature specimens weighting between 60-80 g and spent specimens had a mean weight of 64 g. Because *C. bavaricus* is very rare today, there are no special fisheries for this species anymore. The exceptional large size, high number of gill rakers, small eye and somehow different appearance of the specimen caught in 2003 might be the result of today changed conditions in the deepwater environment or decreased fishing pressure of the lake. Because it was not possible to obtain any tissue for genetic analysis, an introgression of other coregonids could also not be ruled out completely.

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REFERENCES

BIRRER A. & W. SCHWEIZER, 1935. - Der Edelfisch des Vierwaldstätter Sees *Coregonus wartmanni nobilis*, Fatio. Ein Beitrag zur Kenntnis der Coregonen in den Schweizer Seen. *Arch. Hydrobiol*., 29: 617-663.

BUNDESUMWELTMINISTERIUM, 1998. - Nationalbericht biologische Vielfalt. Bericht der Bundesregierung nach dem Übereinkommen über die biologische Vielfalt. 152 p. Bonn: Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit.

CRACRAFT J., 1989. - Speciation and its ontology: The empirical consequences of alternative species concepts for understanding patterns and processes of differentiation. *In*: Speciation and its Consequences (Otte D. & J.A. Endler, eds), pp. 28-59. Sinauer Associates: Sunderland, MA.

DOTTRENS E., 1959. - Systématique des corégones de l'Europe occidentale, basée sur une étude biométrique. *Rev. Suisse Zool*., 66: 1-66.

DOUGLAS M.R., BRUNNER P.C. & L. BERNATCHEZ, 1999. - Do assemblages of *Coregonus* (Teleostei: Salmoniformes) in the central alpine region of Europe represent species flocks? *Mol. Ecol*., 8: 589-603.

DOUGLAS M.R. & P.C. BRUNNER, 2002. - Biodiversity of central Alpine *Coregonus* (Salmoniformes): Impact of one-hundred years of management. *Ecol. Appl*., 12: 154-172.

FATIO V., 1890. - Faune des Vertébrés de la Suisse. V. Histoire naturelle des Poissons. II. Physostomes (suite et fin), Anacanthiens, Chondrostéens, Cyclostomes. LXXX + 576 + 13 p., 4 pls. Georg, Genève & Bâle.

KOTTELAT M., 1997. - European freshwater fishes. An heuristic checklist of the freshwater fishes of Europe (exclusive of former USSR), with an introduction for non-systematists and comments on nomenclature and conservation. *Biol., Bratisl*., Sect. Zool., 52(suppl. 5): 1-271.

MAYDEN R.L., 2002. - On biological species, species concepts and individuation in the natural world. *Fish Fish*., 3: 171-196.

NEHRING S., 2000. - Biodiversität und Naturschutz in aquatischen Systemen. Zum Status eingeschleppter Tierarten. *Wasser & Boden*, 52: 23-36.

RUFLI H., 1978. - Die heutigen sympatrischen Felchenpopulationen (*Coregonus* spp.) des Thuner- und Bielersees und ihre Morphologie. *Schweiz. Ztschr. Hydrol*., 40: 7-31.

RUHLÉ C. & T. KINDLE, 1992. - Morphological comparison of river-spawning whitefish of the alpine Rhine with the whitefish of lake Constance. *Pol. Arch. Hydrobiol*., 39: 403-408.

SCHULZ M. & J. FREYHOF, 2003. - *Coregonus fontanae*, a new spring-spawning cisco from Lake Stechlin, northern Germany (Salmoniformes: Coregonidae). *Ichthyol. Explor. Freshw*., 14: 209-214.

SIEBOLD C.T.E. von, 1863. - Die Süßwasserfische von Mitteleuropa. 430 p. Leipzig: Engelmann.

STEINMANN P., 1950. - Monographie der schweizerischen Koregonen. Beitrag zum Problem der Entstehung neuer Arten. Spezieller Teil. *Schweizer. Ztschr. Hydrol*., 12: 340-491.

VOGT C. & B. HOFER, 1909. - Die Süßwasserfische von Mitteleuropa. Teil I: Text. 558 p. Leipzig: Commissions Verlag, W. Engelmann.

WAGLER E., 1933. - Die Coregonen in den Seen des Voralpengebietes. VII. Der Kilch des Bodensees (*Coregonus acronius* von Rapp). *Int. Rev. Hydrobiol. Hydrogr*., 30: 1-48.

WAGLER E., 1941. - Die Lachsartigen (Salmonidae) II. Teil. Coregonen. *In*: Handbuch der Binnenfischerei Mitteleuropas, Vol. IIIA (Demoll R. & H.H. Maier, eds), pp. 371-501. Stuttgart: Schweizer.

WAGLER E., 1950. - Die Coregonen in den Seen des Voralpengebietes. XI. Herkunft und Einwanderung der Voralpencoregonen. *Veröffentl. Zool. Staatssamml. München*, 1: 3-62.

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