# Description of *Andinoacara stalsbergi* sp. n. (Teleostei: Cichlidae: Cichlasomatini) from Pacific coastal rivers in Peru, and annotations on the phylogeny of the genus

Zuzana Musilová [1,2], Ingo Schindler [3] & Wolfgang Staeck [4]

[1] Department of Zoology, Faculty of Science, Charles University in Prague, Viničná 7, 128 44 Praha, Czech Republic
zuzmus(at)email.cz
[2] Laboratory of fish genetics, Institute of Animal Physiology and Genetics of the Academy of Sciences of Czech Republic, Rumburská 89, 277 21 Liběchov, Czech Republic
[3] Warthestr. 53a, 12051 Berlin, Germany
ingoschindler(at)web.de
[4] Auf dem Grat 41a, 14195 Berlin, Germany

*Received on September 28, 2009, accepted on October 19, 2009.*
*Published online at www.vertebrate-zoology.de on December 11, 2009.*

## > Abstract

*Andinoacara stalsbergi* sp. n. is described from the drainages of trans-andean rivers and lakes at the Peruvian Pacific coast where this species occurs between Río Chira (Depto. Piura) in the north and Río Pisco (Depto. Ica) in the south. It is distinguished from its sister species *A. rivulatus* by the possession of a conspicuous white margin of both the dorsal and caudal fin and scales with light centres and contrasting dark marginal lines forming a fine reticulate pattern on the body sides. Studies based on molecular data confirm the status of *Andinoacara stalsbergi* sp. n. and reveal its phylogenetic relationships to its congeners. The reconstruction of the phylogeny within the genus *Andinoacara* results in the existence of two clades: one with *A. stalsbergi* sp. n., *A. rivulatus*, *A. sapayensis* and *A. biseriatus* and another with the remaining species.

## > Kurzfassung

*Andinoacara stalsbergi* sp. n. wird aus den Einzugsgebieten von Flüssen und Seen an der peruanischen Pazifikküste beschrieben. Dort ist die Art zwischen dem Río Chira (Depto. Piura) im Norden und dem Río Pisco (Depto. Ica) im Süden verbreitet. Von der Schwesterart *A. rivulatus* unterscheidet sie sich durch einen auffälligen weißen Saum entlang der Rücken- und der Schwanzflosse und dunkel geränderte Schuppen mit hellem Zentrum, die auf den Körperseiten ein Netzmuster bilden. Die Analyse molekularer Daten bestätigt den Status von *Andinoacara stalsbergi* sp. n. und zeigt die phylogenetischen Beziehungen zu den übrigen Gattungsmitgliedern. Die Rekonstruktion der Stammesgeschichte in der Gattung *Andinoacara* hat die Existenz von zwei Verwandtschaftslinien zum Ergebnis: eine mit den Arten *A. stalsbergi* sp. n., *A. rivulatus*, *A. sapayensis* und *A. biseriatus* sowie eine zweite mit den übrigen Arten.

## > Key words

Systematic, ichthyology, ecology, reproductive behaviour, Cichlidae, Cichlasomatini, new species, Peru, *Andinoacara*, *Aequidens*, blue acara.

## Introduction

The South American cichlid genus *Andinoacara* Musilová, Říčan & Novák, 2009 belonging to the tribe Cichlasomatini is one of the genera which were recently described as the result of analyses of morphological and molecular data and ensuing nomenclatural revisions. This genus involves six species previously placed in the genus *Aequidens* Eigenmann & Bray, 1894, viz. *Cichlosoma biseriatum* Regan, 1913, *Acara coeruleopunctata* Kner, 1863, *Acara latifrons* Steindachner, 1878, *Cychlasoma pulchrum* Gill, 1858, *Chromis rivulata* Günther, 1860 and *Acara sapayensis* Regan, 1903.

Kullander (1983) demonstrated that *Aequidens* was an unnatural catch-all group. He listed the six species mentioned above among the *Aequidens* species which ought to have been placed into a separate

**Tab. 1**. Primers used for molecular analyses in this study.

| | F | R | citation |
|---|---|---|---|
| **12S rRNA** | AAAAAGCTTCAAACTGGGATT AGATACCCCACTAT | TGACTGCAGAGGGTGACGGGC GGTGTGT | KOCHER *et al*. (1989) |
| **16S rRNA** | CCGGTCTGAACTCAGATCACG | CTGTTTAACAAAAACAT | MARESCALCHI (2005) |
| **cytochrome b** | ACCACCGTTGTTATTCAACTACAAGAA | CCGACTTCCGGATTACAAGACCG | SEVILLA *et a*l. (2007) |
| **ND 4** | TGGAGCTTCTACGTGRGCTTT | CAAAACCTTAATCTYCTACAATGCT | ARÉVALO *et al*. 1994, BIELAWSKY *et al*. (2002) |
| **RAG 1** | CTGAGCTGCAGTCAGTACCATAAGATGT | CTGAGTCCTTGTGAGCTTCCATRAAYTT | GRANDE *et al*. (2004) |
| **rhodopsin** | GCAAGCCCATCAGCAACTTCCG | TGCTTGTTCATGCAGATGTAGA | CHEN *et al*. (2003) |
| **Tmo-4C4** | CGGCCTTCCTAAAACCTCTCATTAAG | GTGCTCCTGGGTGACAAAGTCTACAG | FARIAS *et al*. (1999) |
| **S7 intron 1** | TGGCCTCTTCCTTGGCCGTC | AACTCGTCTGGCTTTTCGCC | CHOW & HAZAMA (1998) |

genus and introduced the term '*Aequidens*' *pulcher* group for them because of lack of an alternative generic allocation. In addition, he later (KULLANDER 1991) used the term '*Aequidens*' *rivulatus* group for '*Aequidens*' *rivulatus* and undescribed forms (cf. STAWIKOWSKI & WERNER 1998) closely related to this species, and eventually showed that the '*Aequidens*' *pulcher-rivulatus* group could have a generic status (KULLANDER 1998). MUSILOVÁ *et al*. (2008) confirmed that the '*Aequidens*' *pulcher-rivulatus* group represents a well supported yet unnamed genus. In their study of the phylogenetic relationships among cichlasomatine cichlids MUSILOVÁ *et al*. (2009) tentatively listed '*Aequidens*' sp. "Silbersaum" as an undescribed species among the members of the '*Aequidens*' *pulcher-rivulatus* group, for which they established the new genus *Andinoacara*.

The species provisionally referred to as '*Aequidens*' sp. "Silbersaum" in Europe or as "Green Terror" in the USA has been known both in the aquarium trade and the popular literature for about forty years (LÜLING 1972; STAECK & LINKE 1985). In the older ichthyological and aquaristic literature it was treated as a form of *A. rivulatus* (e. g. REGAN 1905, EVERMAN & RADCLIFFE 1917, EIGENMANN 1922, LÜLING 1972, WERNER 1983). The formal description of this cichlid is one subject of this paper. In addition the phylogeny within the genus *Andinoacara* is discussed on the basis of a set of molecular data. This is the first molecular phylogenetic analysis including all valid nominal species of *Andinoacara*.

## Material and Methods

Type specimens were fixed in formalin and later transferred into 75% ethanol. The holotype and paratypes are deposited in the fish collection of the Senckenberg Naturhistorische Sammlungen Dresden, Museum für Tierkunde, (MTD F).

The techniques for taking measurements and meristic data follow those described in KULLANDER (1986) and KULLANDER & NIJSSEN (1989). Measurements were made with an electronic digital caliper reading to the nearest 0.1 mm. Figures in brackets after counts indicate the number of specimens examined with that condition. Terminology and methods of measurements of jaws and teeth follow CASCIOTTA & ARRATIA (1993). Scale rows are numbered as described by KULLANDER (1990). Nomenclature of colour patterns follows KULLANDER (1983, 1991). Vertical bars are numbered from the caudal fin to the snout as described by KULLANDER & SILFVERGRIP (1991). According to this approach the caudal spot is counted as bar 1 (homolog to bar 1p in ŘÍČAN *et al*. 2005). The description follows the general format used by KULLANDER (1991).

In the phylogenetic analysis 11 species or forms of *Andinoacara* were studied. We analyzed specimens of seven nominal species, viz. *Andinoacara biseriatus*, *A. coeruleopunctatus*, *A. latifrons*, *A. pulcher*, *A. rivulatus*, *A. sapayensis*, *A. stalsbergi* and four apparently undescribed forms. All specimens used in the molecular analyses were obtained from direct imports to specialized aquarium trade companies in Europe. We studied 2–4 specimens of each species or form, except for *A. coeruleopunctatus* and *A. sapayensis*, as only one individual of these species was available.

In the molecular study eight genetic markers were sequenced, and a data set with the total length of 5627 bp was obtained. Both mitochondrial (16S rRNA, 12S rRNA, cytochrome *b*, ND 4) and nuclear coding (RAG1, rhodopsin, Tmo-4C4) and non-coding (intron 1 in S7 gene) markers were used. We analyzed a data set of eight genes with the exception of *A. sapayensis* because sequences of only two genes of this species were available. The set of primers is listed in Tab. 1.

PCR condition consisted of an initial denaturation step at 94 °C followed by the extension of DNA at

72°C. The annealing temperature of the genes differed: 48 °C for 12S rRNA and 55 °C for rhodopsin, ND 4 and Tmo-4C4. Sequences of the four genes 16S rRNA, cytochrome b, S7 intron 1 and RAG1 were used from previous phylogenetic studies of the tribe Cichlasomatini (Musilová *et al*. 2008, Musilová *et al*. 2009). In case of *A. sapayensis* we followed conditions for PCR described in the previous studies. Sequences of genes newly obtained for this study (12S rRNA, ND 4, rhodopsin, Tmo-4C4) and sequences of *A. sapayensis* (16S rRNA and cytochrome *b*) are available in GenBank.

The substitution model for phylogenetic analysis was suggested by using jModeltest software (Posada, 2008) with Bayesian information criterion (BIC). Phylogenetic analyses of the nuclear and mitochondrial sequence data were performed using Bayesian methods (MrBayes software, Huelsenbeck & Ronquist 2001) with two parallel runs of 20 million generations, each run with 4 chains. Independent model parameters were estimated for each gene partition during Bayesian analysis. Topologies were sampled every 1000 generations and the final results are based on 75% of the obtained trees (15000 trees).

## Abbreviations

| | |
|---|---|
| **BIC** | Bayesian information criterion; method used in molecular analyses for choosing an apropriate model of molecular evolution |
| **E1** | Row of scales in the horizontal series directly above the longitudinal row including the lower lateral line |
| **MTD F** | Senckenberg Naturhistorische Sammlungen Dresden, Museum für Tierkunde, Fischsammlung |
| **ND 4** | NADH dehydrogenase subunit 4, mitochondrial gene for enzyme from respiratory complexes |
| **PCR** | Polymerase chain reaction, method used for amplification of selected gene markers |
| **RAG1** | Recombination activating gene, subunit 1, nuclear genetic marker |
| **SL** | Standard length |
| **TL** | Total length |
| **12S rRNA** | Mitochondrial genetic marker coding ribosomal RNA (part of mitochondrial ribosomes). |
| **16S rRNA** | Mitochondrial genetic marker coding ribosomal RNA (part of mitochondrial ribosomes) |

## *Andinoacara stalsbergi* sp. n.

Figs. 1–5, Tables 2–3

**Holotype.** MTD F 31782, adult female, 103.0 mm SL, Peru, Depto. Ica, Rio Pisco, 13º 43' 26" S, 75º 58' 59" W; *leg*. A. Stalsberg, 2008.
**Paratypes.** MDT F 31783–31794, 12 ex., 25.3-68.0 mm SL, Peru, Depto. Lambayeque, vicinity of Chiclayo; licensed and confirmed import for aquarium trade, *don*. Musilová. MDT F 31795–31797, 3 ex., 98.9–113.0 mm SL, Peru, Depto. Piura, few km north of Piura, Laguna Ñapique, 5º 30' 27" S, 80º 42' 40" W; *leg*. A. Stalsberg, 2008. MTD F 31798–31801, 4 ex., 89.6–108.2 mm SL, data like holotype. Not catalogued, 1 ex., 73.3 mm SL, alizarin red stained and dissected, data like holotype.

**Diagnosis.** A species of the *Andinoacara rivulatus* group. It is most similar to *A. rivulatus* with which it shares the comparatively large size (TL > 200 mm in males), the colour pattern of the cheeks and a light vertical stripe anterior and posterior to the rectangular midlateral spot. It is readily distinguished from this species by specific colour characteristics, viz. having (1) a conspicuous white margin in both the dorsal and caudal fin and (2) on the body sides scales with light centres and contrasting dark marginal lines forming a fine reticulate pattern.

**Description.** Refer to Figs. 1–4 for general appearance and colour pattern. Morphometric data of eight specimens (89.6–113.0 mm SL) are summarised in Tab. 2. Counts from 12 specimens (65.8–113.0 mm SL), osteological characters from a dissected specimen (73.3 mm SL).

Body moderately deep (body depth 42–49% of SL) and laterally compressed. Snout round, moderately long. Jaws isognathus. Lips moderately thick. Interorbital area convex. Anterior dorsal head profile straight, on nape curved; ventral contours less arched. Pre-pelvic and abdominal contour straight or slightly concave. Dorsal-fin base almost straight. Caudal peduncle with straight dorsal and ventral edge. In frontal aspect outline of body elliptic with rounded nape and chest.

Uniserial predorsal scale pattern. Cheek scales in 3 series. Dorsal, anal, pelvic and pectoral fins naked. Caudal-fin base densely scaled. Scales in E1 row 24(2) or 25(10). Scales on upper lateral line 15(1), 16(2) or 17(9), on lower lateral line 8(1), 9(4) or 10(7), including 1 or 2 on caudal fin base.

Soft portion of anal and dorsal fin pointed, but not produced, reaching anterior caudal fin in adult specimens. Caudal fin round or slightly subtruncate; caudal fin length about $^1/_4$ to almost $^1/_3$ of SL. Pelvic fins rounded, extending to anus. Pectoral fin rounded,

**Fig. 1**. *Andinoacara stalsbergi* sp. n., holotype, female 103 mm SL, MTD F 31782.

**Fig. 2**. Adult female of *Andinoacara stalsbergi* sp. n., from the vicinity of Chiclayo (Depto. Lambayeque), TL 116 mm. Live specimen photographed in aquarium.

with 13–14 rays. Dorsal fin XIII.12(1), XIII.13(1), XIV.11(3) or XIV.12(7). Anal fin III.8(8), III.9(3) or III.10(1).

On first gill arch 2 or 3 small gill rakers on epibranchial, 1 in the angle and 9–10 (n=5) externally on ceratobranchial. Fourth ceratobranchial with 5 tooth plates and 3 to 7 teeth on each plate. Lower pharyngeal tooth plate (Fig. 5) robust, moderately long (width of bone 83–85% of its length; n=2), with well-ordered teeth; length of dentigerous area 85% of its width; 14–17 teeth in posterior row (n=2), 6–9 teeth in median row (n=2); teeth obviously lost were also counted. Oral jaw teeth conical with recurved tips. In upper jaw hemiseries 15–22 outer row teeth and in lower jaw hemiseries 17–23. Length of dentigerous arm of premaxilla shorter than length of ascending arm (premaxillary ascending arm length/dentigerous arm length ≈ 1.6); width of the ascending arm about 15% of its length.

**Fig. 3**. Topotypic female of *Andinoacara stalsbergi* sp. n. showing breeding colour pattern in aquarium. Photo: A. Stalsberg.

**Fig. 4**. Adult male of *Andinoacara stalsbergi* sp. n. showing neutral colour pattern in aquarium.

Lower jaw comparatively high (anguloarticular depth about 72% of length, coulter area depth about 43% of anguloarticular length). Coulter area deeper than its length (coulter area depth/coulter area width ≈ 1.3). Dorsal margin of hyoid more or less straight, without a deep notch.

**Colouration in life.** Based on observations on specimens kept in aquarium and photos taken immediately after capture. Forehead, nape and pre-dorsal part of dorsum uniformly greyish or light brown. On the body sides each scale with iridescent or metallic green centre and contrasting dark brown marginal line. The dark scale margins form a fine reticulate pattern which is particularly prominent in adult specimens. Cheeks with two to four narrow oblique opalescent green lines and several small buccal dots of the same colour. Dark cheek spot in the corner of the preopercle usually vis-

**Tab. 2**. Body proportions of *Andinoacara stalsbergi*. Measurements of holotype (MTD F 31782 ) and seven paratypes (MTD F 31795–31797, MTD F 31798–31801) in percent of SL (except SL in mm); min = lowest value, max = highest value, mean = arithmetic mean, sd = standard deviation.

| | min | max | mean | sd |
|---|---|---|---|---|
| Standard length | 89.6 | 113.0 | 100.8 | 8.2 |
| Body depth | 42.0 | 48.9 | 44.8 | 2.60 |
| Head length | 32.3 | 36.0 | 34.6 | 1.27 |
| Eye diameter | 6.7 | 8.2 | 7.6 | 0.47 |
| Interorbital width | 12.0 | 14.1 | 13.0 | 0.80 |
| Preorbital depth | 8.6 | 11.1 | 10.0 | 0.70 |
| Predorsal length | 41.4 | 47.7 | 44.0 | 2.30 |
| Prepelvic length | 40.7 | 45.3 | 41.9 | 1.72 |
| Preanal length | 65.3 | 73.2 | 69.8 | 2.25 |
| Dorsal-fin base length | 52.9 | 60.4 | 56.3 | 2.54 |
| Anal-fin base length | 20.1 | 23.9 | 21.5 | 1.47 |
| Pectoral-fin length | 26.8 | 30.4 | 28.5 | 1.35 |
| Peduncle depth | 15.3 | 17.9 | 16.6 | 0.78 |
| Peduncle length | 14.0 | 15.5 | 14.9 | 0.80 |

ible only during brood care. Lips, lower region of preopercle and gill cover iridescent green. Iris golden.

No horizontal lateral band. Midlateral spot black, squarish or rectangular, extending dorso-ventrally from $^3/_4$ of El scales 8–10, 9–11 or 9–12 to all of these scales in E2 and E3 row above. Anterior and posterior to midlateral spot with contrasting narrow vertical white stripe which fades in dorsal and ventral region. Sometimes with three ill-defined wide dark vertical bars and narrow light interspaces behind the midlateral spot. Usually no caudal spot (if visible: small, vertically extended, positioned on level of lower lateral line).

Dorsal fin grey, with narrow dark submarginal band and white lappets forming a conspicuous white margin; soft part with iridescent streaks on the membranes. Anal fin grey with blackish margin and small iridescent green dots and short lines. Caudal fin grey, with darker distal region, a conspicuous white posterior margin and a pattern of tiny greenish dots. Pelvic fins grey, darker along anterior margin, with green first interradial membrane and greenish dots or short streaks inwardly. Pectoral fins hyaline and colourless. After spawning and during parental care both sexes develop a very dark, almost blackish colouration with two contrasting white vertical stripes anterior and posterior to midlateral spot.

**Colouration in alcohol.** Based on holotype with notes on paratype specimens. Body sides grey, darker on nape and back. Scales on sides with narrow black margin. Snout and cheeks grey. Lips dark grey. Gill cover, preopercle and branchiostegal region dark grey. Two or three dark preorbital stripes and several irregular short streaks or dots. Supraorbital markings indistinct and faint. Suborbital stripe reduced to a short dark marking (often masked by dark head sides) in the corner of the preopercle.

No continious lateral band. Bar 1 (caudal spot) narrow, prominent and blackish, in the centre of the caudal-fin base, not reaching ventral or dorsal edges of it; bar 2 on caudal peduncle; bar 3 on anterior part of caudal peduncle between posterior rays of dorsal fin and anal fin, in smaller specimens (< 70 mm SL) often split into two parallel vertical bars; bar 4 and 5 fused in adult specimens, but separate in smaller ones; bar 6 darker than the other bars, straight, not vertically split, on both sides with contrasting narrow light margin; bar 7 and 8 indistinct, usually fused. Midlateral spot black, on upper half of bar 6.

Dorsal fin dark grey with light marginal band and light grey streaks in its soft part. Anal fin grey with darker marginal band and light grey streaks in posterior portion. Caudal fin grey, with light grey streaks in posterior portion and contrasting light distal margin. Pelvic fins dark grey. Pectoral fins hyaline.

**Sexual dimorphism.** There are no obvious external sex differences in fin length or intensity of colour pattern. However, observations under aquarium conditions revealed that there is a distinct size difference between males and females and that in addition dominant males develop a prominent nuchal hump.

**Geographical distribution.** *Andinoacara stalsbergi* is distributed in trans-andean rivers and lakes at the Peruvian Pacific coast. The distribution of this species in the Pacific slope of western Peru between Río Chira (Depto. Piura) in the north and the Río Pisco (Depto. Ica) in the south is well documented (cf. STAWIKOWSKI

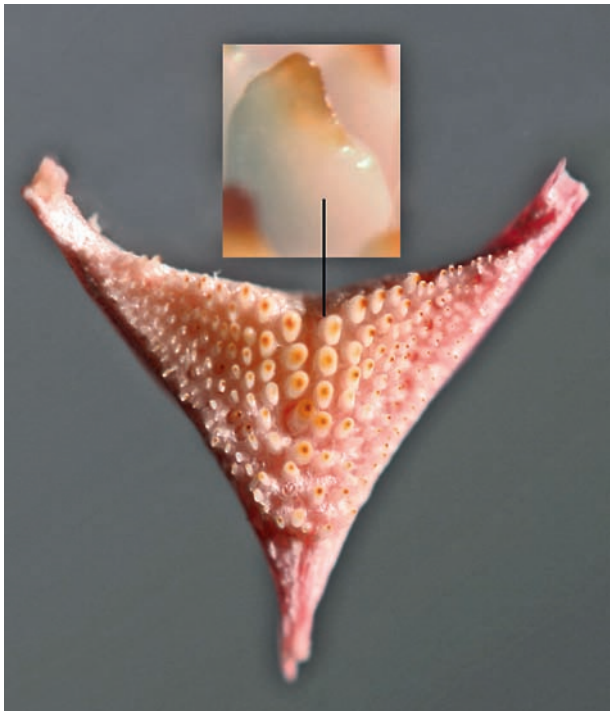

**Fig 5**. Lower pharyngeal tooth plate of *A. stalsbergi* sp. n. (73.3 mm SL).

& Werner, 1998). Collecting sites confirmed by Stalsberg (personal communication) were (from the south to the north) Río Pisco, Río Cañete (Lunahuana: 13º01'57''S, 76º12'02'' W), Río Mala, Río Lurin, Laguna Ñapique (05º30'27" S, 80º42'40" W), Lago San Ramón, Río Piura, Quebrada Carneros, Quebrada Onda, Río Pidregal and Quebrada Samana (tributary to Río Chira). Additional collecting sites are the Laguna de Végueta (Lüling 1973) and Pacasmayo (Everman & Radcliffe 1917). In the vicinity of Tumbes (Depto. Tumbes) in the extreme north of Peru (Río Tumbes and Río Zarumilla) and in the adjacent Pacific slope of Ecuador this species is replaced by another species of the *A. rivulatus* group, which is also known in popular aquarium literature as "*Aequidens*" sp. "Goldsaum" and treated as *A. rivulatus* by Stawikowski & Werner (1998) and Kullander (2003).

**Ecological notes.** Lüling (1973) published a detailed description of the Laguna de Vegueta (approx. 11° 00' S, 77° 08' W), a collecting site of *Andinoacara stalsbergi*. The banks of this brackish lake situated close to the shoreline of the Pacific were partly covered with aquatic and submerged terrestrial vegetation (*Hydrocotyle bonariensis* and *Bacopa monnieri*). The associated fish fauna included *Bryconamericus peruvianus, Lebiasina bimaculata* (Characidae), *Poecilia reticulata* (Poeciliidae) *Dorminator latifrons* (Eleotridae). Water data collected in November 1970: pH 7.7; electrical conductivity 4280 µS/cm; total and temporary hardness 6.7 °dH. Lüling (1973) advanced the hypothesis that the Characidae and Poeciliidae are an important source of food for the cichlids.

Stalsberg, who repeatedly caught this cichlid between 1994 and 2008 in different years at many localities, collected additional ecological data at several collecting sites (from the south to north): (1) Depto. Ica: Río Pisco near Independencia (13º43'25" S, 75º58'59" W). At the collecting site the rather clear river was approx. 10 m wide. Its bottom was covered with sand and rocks. There was no submerged vegetation. Water data: water temperature 25.5 ºC, pH 8.3, total hardness > 40 °dH, temporary hardness 7 dH. (2) Depto. Piura: Laguna Ñapique about 60 km south of Piura (05º30'27" S, 80º42'40" W). Water data collected in August: water and air temperature 26 ºC, pH 9.2, total hardness >30 °dH, temporary hardness 4 ºdH. The water of the Lake was turbid and its bottom sandy. (3) Depto. Piura: Laguna San Ramón about 40 km south of Piura. Water data: water temperature 28.2 ºC, pH 9.0, total hardness 26 °dH, temporary hardness 5 ºdH, electrical conductivity 1700 µS/cm. The associated fish fauna included *Tilapia* sp. (Cichlidae) and *Bryconamericus peruanus* (Characidae). (4) Depto. Piura: Quebrada Saman, tributary to Río Chira at Pueblo Mallares. Water data: water temperature 22.5 ºC, air temperature 27 °C, pH 8.2, total hardness 31 °dH, temporary hardness 15 ºdH, electrical conductivity 1850 µS/cm. (5) Depto. Piura: Río Pidregal in the northwest of Sullana. Water data collected in August: water temperature 24 ºC, air temperature 28 ºC, pH 8.3, total hardness 15 °dH, temporary hardness 13 ºdH, electrical conductivity 270 µS/cm.

The available ecological data reveal that *Andinoacara stalsbergi* is well adapted to very alkaline and hard water rich in dissolved minerals and even tolerates brackish water (Lüling 1973).

**Reproductive behaviour.** Observations under aquarium conditions showed that *Andinoacara stalsbergi* is a monogamous substratum spawner and that both sexes share in all the duties of brood care. The female, however, is usually the more active partner as long as the pair cares for eggs or larvae, while the male defends the spawning territory against intruders. Like most other open brooders these cichlids deposit their eggs on a horizontal surface. At 27 °C hatching occurs about two days postspawning, and the fry attempt swimming seven days thereafter. The male and female fish practice long-term biparental defense of their mobile fry. A detailed description of the reproductive behaviour was published by Werner (1983).

**Etymology.** Named in honour of Alf Stalsberg (Tjodalyng, Norway), the collector of the holotype, in recognition of his longstanding commitment to increase the knowledge about cichlid fishes.

**Fig. 6**. Adult male of *Andinocara rivulatus* from Río Tumbes photographed in aquarium.

## Discussion

*Andinoacara stalsbergi* is most closely related to *A. rivulatus* (Fig. 6), its sister species. Both differ from other species of *Andinoacara* by the lack of conspicuous dark nape markings (versus distinct dark supraorbital marks in species of both the *A. pulcher* group and of the related genera *Bujurquina* and *Tahuantinsuyoa*; cf. KULLANDER 1986, 1991), larger size (adult males > 150 mm TL versus < 150 mm TL in the previously mentioned taxa; cf. EIGENMANN 1922) and a trend towards more gill rakers (usually 9 or 10 rakers on ceratobrachial of outer gill arch versus usually < 9 in the remaining species of *Andinoacara*; cf. REGAN 1905, 1913, EIGENMANN 1922).

Although *A. stalsbergi* is very similar to *A. rivulatus* in morphometric and meristic data, general appearance and colouration of its head, these two allopatric species can readily be distinguished for distinctive specific colour patterns: *Andinoacara stalsbergi* has light scale centres and dark scale edges forming a reticulate pattern on the flanks (versus light scale edges and dark scale centres forming a pattern of horizontal lines in *A. rivulatus*) and a prominent white margin of the dorsal and caudal fin (versus a broad orange margin in *A. rivulatus*). The genetic differences between *A. stalsbergi* and its congeners (Tab. 3) provide additional arguments for its taxonomical separateness according to the evolutionary species concept (WILEY 1978).

*Andinoacara biseriatus* listed as a member of the *pulcher* group by KULLANDER (1998) and included in the *rivulatus* group by STAWIKOWSKI & WERNER (1998) clustered as the basal sister taxon of the *rivulatus-stalsbergi* clade (Fig. 7). This species differs from *A. stalsbergi* by the possession of dark rimmed scales on its nape (versus scales without dark posterior rim), a dark dot in the centre of each scale on body and opercle (versus dark edges, but no dark dots in *A. stalsbergi*), a caudal fin with a narrow reddish margin (versus caudal fin with broad whitish margin), a lateral spot positioned more dorsally than in *A.stalsbergi*, an additional spot (more prominent in females) in the dorsal fin above the bar with lateral spot (versus no such spot in *A. stalsbergi*) and, according to REGAN (1913), frequently 2 rows of scales on its cheek (versus 3 rows of scales in *A. stalsbergi*).

In the result of the phylogenetic analysis *Andinoacara sapayensis* clustered as a sister taxon of the rivulatus-stalsbergi clade. Adult specimens of *Andinoacara stalsbergi* differ significantly from *A. sapayensis* by the possession of only 3 bars between midlateral spot and caudal spot (versus four bars; compare Fig. 1-3 with Plate 31, Fig. 1 in EIGENMANN 1922), by the number of gill rakers on first outer gill arch (8–10 in *A. stalsbergi* versus <8 in *A. sapayensis*; cf. REGAN 1905, EIGENMANN 1922) and the lack of distinct dark supraorbital marks (versus possession of prominent supraorbital marks in *A. sapayensis*).

The molecular studies confirm the status of *Andinoacara stalsbergi* and reveal its phylogenetic relationships to its congeners (Fig. 7). The reconstruction of the phylogeny within the genus *Andinoacara* results in the existence of two clades. One consists of three valid species (i. e. *A. latifrons*, the type species

**Tab. 3**. Uncorrected p-distance between *Andinoacara stalsbergi* sp. n. and the two closely related species *A. rivulatus* (sister species) and *A. biseriatus* (1st & 2nd column). Average distance between nominal species of *Andinoacara,* including *A. stalsbergi* sp. n. in 3rd column.

| | *A. stalsbergi* vs. *A. rivulatus* | *A. stalsbergi* vs. *A. biseriatus* | average *Andinoacara* |
|---|---|---|---|
| total (8 genes) | 1.6% | 5% | 4.5% |
| 12S rRNA | 0.8% | 2.6% | 1.6% |
| 16S rRNA | 0.8% | 2.7% | 2% |
| cytochrome b | 3.9% | 14.1% | 11.4% |
| NADH 4 | 4.3% | 12.8% | 13% |
| RAG 1 | 0.3% | 0.3% | 0.7% |
| rhodopsin | 0% | 0.7% | 0.7% |
| Tmo-4C4 | 0.2% | 1% | 1.5% |
| S7 intron 1 | 1.6% | 1.4% | 2.5% |

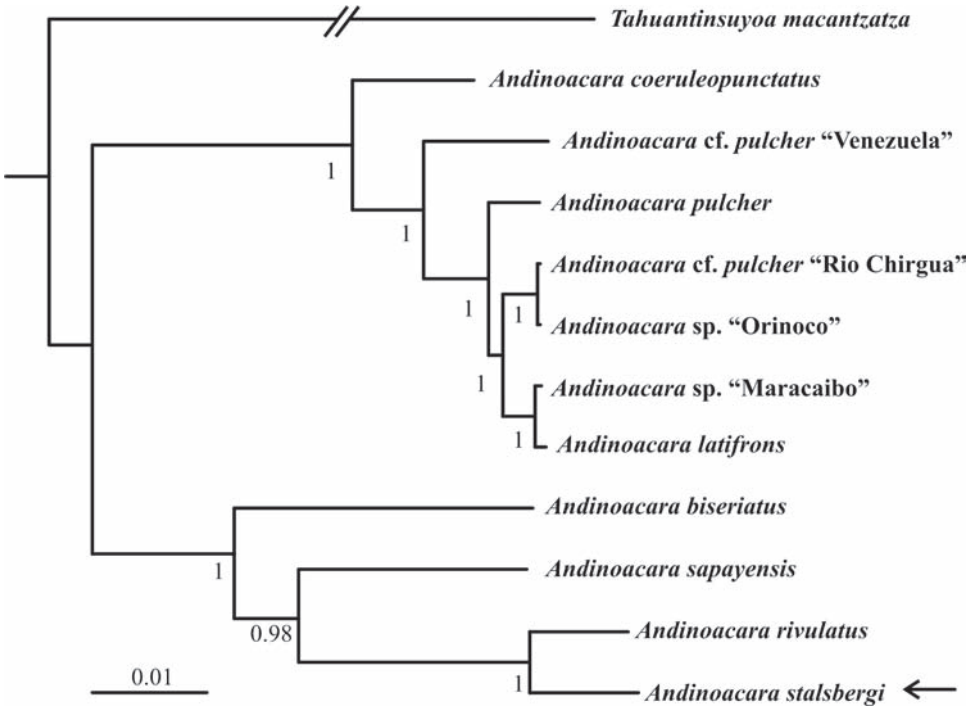


**Fig. 7**. Phylogenetic relationships within the genus *Andinoacara* based on a data set of eight genes (16S rRNA, 12S rRNA, cytochrome b, ND 4, S7 intron 1, RAG1, Rhodopsin, Tmo-4C4). Analysis was performed by using MrBayes software with two parallel runs of 20 million generations and sampling every 1000 trees. The model parameters suggested by jModeltest were applied. The phylogenetic position of *Andinoacara stalsbergi* sp. n. is marked by the indicator.

of *Andinoacara, A. coeruleopunctatus* and *A. pulcher*) and several possibly undescribed forms: *Andinoacara* sp. „Rio Chirgua" and *A.* sp. „Orinoco" representing separate lineages of fishes living in Venezuela and differing from *A. pulcher* and *A. latifrons* in their colouration. This group of „blue acaras" was referred to as „*Aequidens*" sp. „Orinoco" in Stawikowski & Werner (1998). But despite considerable differences, further morphological studies are required to confirm their status as new species. *Andinoacara* sp. "Maracaibo" (Stawikowski & Werner 1998) is endemic to the drainages of Lago de Maracaibo in western Venezuela and represents another undescribed form with limited distribution. However, in the results of our analyses we found only minor genetic difference between this form and *A. latifrons* living in eastern Colombia. Morphological comparisons of both are still missing because of the lack of material.

The specimens of *A. pulcher* used in our analyses were collected in Trinidad. They are genetically identical with *A. pulcher* obtained from Czech and German aquarium trade. Eventually *A.* sp. "Venezuela" appears to represent another form of „blue acara" with uncertain taxonomic position, for conclusive evidence is missing as only few specimens were available.

The second clade of *Andinoacara* is formed by *A. biseriatus*, *A. sapayensis, A. rivulatus* and *A. stalsbergi*. The two latter species clustered in our analyses as sister species, but are well distinguishable from each other on the basis of molecular data.

The two clades defined above correspond to the '*Aequidens*' *pulcher* group and the '*Aequidens*' *rivulatus* group respectively, previously distinguished by KULLANDER (1998). The only exception is *A. biseriatus* as it was considered by KULLANDER (1998) as a species of the '*A.*' *pulcher* group, but, by contrast, clustered as a basal species in the second clade, (i.e. with *A. sapayensis, A. rivulatus* and *A. stalsbergi*) in the results of our study of molecular phylogeny.

The genetic distance among particular species of *Andinoacara* (Tab. 3) varies in the different loci used in the molecular analysis. The average distance between the valid nominal species of *Andinoacara* was found in the range between 0.7% and 13% of uncorrected p-distance. The distance between *A. stalsbergi* and its sister species *A. rivulatus* varies up to 4.3% in different genes (Tab. 3).

## Acknowledgements

Part of this work was carried out by using the resources of the Computational Biology Service Unit from Cornell University. Financial support was provided for the first author by GAUK 139407, Deutsche Cichliden Gesellschaft, and the foundation of the Centre for Biodiversity LC06073 (MSMT). The Institute of Animal Physiology and Genetics receives continuous support from IRP IAPG (No. AV0Z50450515). We are indebted to ALF STALSBERG for providing study material, photos and information on his collecting sites and thank AXEL ZARSKE (MTD) for depositing the material in his institute.

## References

AREVALO, E.; DAVIS, S.K. & SITES, J.W. (1994): Mitochondrial DNA sequence divergence and phylogenetic relationships among eight chromosome races of the *Sceloporus grammicus* complex (Phrynosomatidae) in central Mexico. – Systematic Biology, **43**: 387–418.

BIELAWSKY, J.; BRAULT, A. & GOLD, J. R. (2002): Phylogenetic relationships within the genus *Pimephales* as inferred from ND4 and ND4L nucleotide sequences. – Journal of Fish Biology, **61**: 293–297.

CASCIOTTA, J. R. & ARRATIA, G. (1993): Jaws and teeth of American Cichlids (Pisces: Labroidei). – Journal of Morphology, **217**: 1–36.

CHEN, W. J.; BONILLO, C. & LECOINTRE, G. (2003): Repeatability of clades as a criterion of reliability: a case study for molecular phylogeny of Acanthomorpha (Teleostei) with larger number of taxa. – Molecular Phylogenetics and Evolution, **26**: 262–288.

CHOW, S. & HAZAMA, K. (1998): Universal PCR primers for S7 ribosomal protein gene introns in fish. – Molecular Ecolology, **7**: 1255–1256.

GRANDE, T.; LATEN, H. & LOPEZ, J.A. (2004): Phylogenetic relationships of extant esocid species (Teleostei: Salmoniformes) based on mophological and molecular characters. – Copeia, **2004**: 743–757.

EIGENMANN, C. H. (1922): The fishes of western South America, Part I. The fresh-water fishes of northwestern South America, including Colombia, Panama, and the Pacific slopes of Ecuador and Peru, together with an appendix upon the fishes of the Rio Meta in Colombia. – Memoirs of the Carnegie Museum, **9**: 1–346, Pls. 1–38.

EVERMANN, B. W. & RADCLIFFE, L. (1917): The fishes of the west coast of Peru and the Titicaca Basin. – Bulletin of the United States National Museum, No. **95**: 1–166.

FARIAS, I. P., ORTÍ, G.; SAMPAIO, I.; SCHNEIDER, H. & MEYER, A. (1999): Mitochondrial DNA phylogeny of the family Cichlidae: monophyly and fast molecular evolution of the Neotropical assemblage. – Journal of Molecular Evolution, **48**: 703–711.

HUELSENBECK, J. P. & RONQUIST, F. (2001): MrBayes: Bayesian inference of phylogeny. – Bioinformatics, **17**: 754–755.

KOCHER, T. D.; THOMAS, W. K.; MEYER, A.; EDWARDS, S. V.; PAABO, S.; VILLABLANCA, F. X. & WILSON, A. C. (1989): Dynamics of mitochondrial DNA evolution in animals: amplification and sequencing with conserved primers. – Proceedings of the National Academy of Sciences of the United States of America, **86**: 6196–6200.

KULLANDER, S. O. (1983): A revision of the South American Cichlid genus *Cichlasoma* (Teleostei: Cichlidae). – Swedish Museum Natural History. Stockholm, 296 pp.

KULLANDER, S. O. (1986): Cichlid fishes of the Amazon River Drainage of Peru. – Swedish Museum Natural History. Stockholm, 431 pp.

KULLANDER, S. O. (1990): *Mazarunia mazarunii* (Teleostei: Cichlidae), a new genus and species from Guyana, South America. – Ichthyological Exploration of Freshwaters, **1**: 3–14.

KULLANDER, S. O. (1991): *Tahuantinsuyoa chipi*, a new species of Cichlid fish from the Rio Pachitea drainage in Peru. – Cybium, **15**: 3–13.

KULLANDER, S. O. (1998): A phylogeny and classification of the South American Cichlidae (Teleostei: Perciformes). In: Malabarba, L. R.; Reis, R. E.; Vari, R. P.; Lucena, Z. M. S.; Lucena, C. A. S. (eds.): Phylogeny and classification of Neotropical fishes, 461–498. – EDIPUCRS, Porto Alegre, Brazil.

KULLANDER, S. O. (2003): Family Cichlidae (Cichlids). In: REIS, R. E., S. O. KULLANDER & C. J. FERRARIS, Jr. (eds.): Check List of the Freshwater Fishes of South America and Central America: 605–654. – EDIPUCRS, Porto Alegre, Brazil.

KULLANDER, S. O. & NIJSSEN, H. (1989): The Cichlids of Surinam. – Leiden. Brill, 256 pp.

KULLANDER, S. O. & SILFVERGRIP, A. M. C. (1991): Review of the South American cichlid genus *Mesonauta* Günther

(Teleostei, Cichlidae) with descriptions of two new species. – Revue Suisse de Zoologie, **98**: 407–448.

Lüling, K. H. (1972): *Aequidens rivulatus*. – Tatsachen & Informationen aus der Aquaristik, **6**, No. 19: 2–3.

Lüling, K. H. (1973): Die Laguna de Vegueta an der Küste Mittelperus und ihre Fische, insbesondere *Aequidens rivulatus* (Guenther 1859). – Zoologische Beiträge, Neue Folge, **19**: 93–108.

Marescalchi, O. (2005): Karyotype and mitochondrial 16S gene characterizations in seven South American Cichlasomatini species (Perciformes, Cichlidae). – Journal of Zoological Systematics & Evolutionary Research, **43**: 22–28.

Musilová, Z.; Říčan, O.; Janko, K. & Novák, J. (2008): Molecular phylogeny and biogeography of the Neotropical cichlid fish tribe Cichlasomatini (Teleostei: Cichlidae: Cichlasomatinae). – Molecular Phylogenetics and Evolution, **46**: 659–672.

Musilová, Z.; Říčan, O. & Novák, J. (2009): Phylogeny of the neotropical cichlid fish tribe Cichlasomatini (Teleostei: Cichlidae) based on morphological and molecular data, with the description of a new genus. – Journal of Zoological Systematics and Evolutionary Research, **47**: 234–247.

Posada, D. (2008): jModelTest: Phylogenetic model averaging. – Molecular Biology and Evolution, **25**: 1253–1256.

Regan, C. T. (1905): A revision of the fishes of the South-American cichlid genera *Acara*, *Nannacara*, *Acaropsis*, and *Astronotus*. – Annals and Magazine of Natural History, Series 7, **15**: 329–347.

Regan, C. T. (1913): The fishes of the San Juan River, Colombia. – Annals and Magazine of Natural History, Series 8, **12**: 462–473.

Říčan, O.; Musilová, Z.; Muška, M. & Novák, J. (2005): Development of coloration patterns in neotropical cichlids (Teleostei: Cichlidae: Cichlasomatinae). – Folia Zoologica, **54**, Monograph 1: 1–46.

Sevilla, R. G.; Diez, A.; Noren, M.; Mouchel, O.; Jerome, M.; Verrez-Bagnis, V.; van Pelt, H.; Favre-Krey, L.; Krey, G. & Bautista, J.M. (2007): Primers and polymerase chain reaction conditions for DNA barcoding teleost fish based on the mitochondrial cytochrome b and nuclear rhodopsin genes. – Molecular Ecology Notes, **7**: 730–734.

Staeck, W. & Linke, H. (1985): Amerikanische Cichliden II: Große Buntbarsche. – Tetra Verlag. Melle. 165 pp.

Stawikowski, R. & Werner, U. (1998): Die Buntbarsche Amerikas. Band 1. – Ulmer, Stuttgart, 540 pp.

Werner, U. (1983): Silbersaumbuntbarsch, *Aequidens rivulatus*. – Das Aquarium, **17** (7): 355–360.

Wiley, E. O. (1978): The evolutionary species concept reconsidered. – Systematic Zoology, **27**: 17–26.