Haplochromis vanheusdeni,
a new haplochromine cichlid species
from the Great Ruaha River drainage, Rufiji basin, Tanzania

(Teleostei, Perciformes, Cichlidae)

Frederic D. B. Schedel, John P. Friel & Ulrich K. Schliewen

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Haplochromis vanheusdeni, new species, is described from three streams and one river draining the southern flanks of the Udzungwa mountains, Rufiji basin (Republic of Tanzania). This rheophilic haplochromine cichlid species is distinguished from all other haplochromines currently placed in the genera *Orthochromis* Greenwood, 1954 and *Schwetzocochromis* Poll, 1948, and from rheophilic species of the genus *Haplochromis* Hilgendorf, 1888 (*H. bakongo* Thys van den Audenaerde, 1964; *H. snoeksi* Wamuini Lunkayilako & Vreven, 2010) by having large ocellated egg spots on the anal fin (vs. no egg spots or only non-ocellated egg spots), by hypuralia 1 and 2 and hypuralia 3 and 4 either clearly separated or separated by a clearly visible seam (vs. never fused into a single seamless unit), and by a combination of meristic characters.

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Introduction

With approximately 1500 species, the African haplochromine cichlid fishes represent one of the most diverse vertebrate clades on our planet and undoubtedly the most diverse cichlid clade (Salzburger 2009). The majority of this diversity is endemic to the East African Great Lakes, only comparatively few species exclusively inhabit rivers (Greenwood 1979), and even fewer rheophilic species have been described. Although not precisely defined, riverine cichlids are considered rheophilic, if they have evolved presumed morphological adaptations to a bottom-oriented life in strong current, i. e. a comparatively slender body, rounded pelvic fins, and a reduced head, nape and chest squamation (Roberts & Stewart 1976). Extremely adapted species include members of the non-haplochromine genera *Teleogramma* Boulenger, 1899, *Steatocranus* Boulenger, 1899 or *Gobiocichla* Kanazawa, 1951, but also a number of rheophilic *Haplochromis*-related taxa are known. Exclusively rheophilic haplochromine genera are *Schwetzochromis* Poll, 1948 (type species *S. neodon* Poll, 1948) and *Orthochromis* Greenwood, 1954 (type species *O. malagaraziensis* (David, 1938), originally described in the genus *Haplochromis* Hilgendorf, 1888). Outside of these genera, additional rheophilic species were placed in the catch-all genus *Haplochromis*, i. e. *Haplochromis bakongo* Thys van den Audenaerde, 1964 or *H. snoeksi* Wamuini Lunkayilakio & Vreven, 2010.

Except for one species from the Cunene River in Angola and Namibia, i.e. *O. machadoi* (Poll, 1967), all rheophilic haplochromines were described from the Congo basin including its easternmost affluent, the Malagarasi. Therefore it came as a surprise when an undescribed slender cichlid with rounded pectoral fins and a reduced head squamation, preliminarily identified as an *Orthochromis* sp., was collected by one of the authors (JFP) and colleagues in East African streams and rivers draining into the Indian Ocean, i.e. in the Great Ruaha drainage of Tanzania. After photographs of living specimens became available (van Heusden 2011), it became apparent that the species does not fit all characters listed in the recently revised diagnosis of *Orthochromis* and *Schwetzochromis* by De Vos & Seegers (1998). They rather carry large ocellated egg spots on the central part of the anal fin, which are lacking or are very small and non-ocellated in *Orthochromis*; and they have well defined lachrymal stripes, which are lacking in *Schwetzochromis*. Further, recent molecular phylogenetic results suggested strongly, that cichlids currently placed in *Orthochromis* and *Schwetzochromis* are not monophyletic, but rather represent several distinct lineages within a conglomerate of ill-defined, often polyphyletic haplochromine cichlid genera (Salzburger et al. 2002, Koblmüller et al. 2008, Schwarzer et al. 2012, Dunz & Schliewen 2013). In the light of the apparent polyphyly of *Orthochromis*-like rheophilic taxa and accepting the need to revise the generic classification of haplochromine cichlids in general, we follow the logic of van Oijen et al. (1991) and van Oijen (1996) and describe the new species in the catch-all genus *Haplochromis* instead of redefining existing riverine haplochromine genera without a full generic revision (e.g. Wamuini-Lunkayilikako & Vreven 2010, de Zeeuw et al. 2013).

Material and methods

Material

One hundred sixty nine specimens of rheophilic haplochromine cichlid specimens were investigated for morphological comparisons (see Appendix). These are deposited in CUMV, Cornell University Museum of Vertebrates, Ithaca; NHM, Natural History Museum London; MRAC, Royal Museum for Central Africa, Tervuren; ZSM, Bavarian State Collection of Zoology, Munich; and MKL, the personal collection of O. Seehausen, Swiss Federal Institute of Aquatic Sciences and Technology, Dübendorf (see Appendix I). Since the species described herein is a slender rheophilic species, we compared it with all haplochromine cichlid species currently placed in the rheophilic genera *Orthochromis* Greenwood, 1954 and *Schwetzochromis* Poll, 1948 according-

ing the last revision by De Vos & Seegers (1998), as well as with five additional described or undescribed riverine haplochromines sharing with the new species an *Orthochromis*-like body shape, i.e. a slender body and rounded pelvic fins. Comparative data for *O. mazimeroensis* De Vos & Seegers, 1998, *O. mosoensis* De Vos & Seegers, 1998, *O. rugufuensis* De Vos & Seegers, 1998 were taken from the original description, since no specimens were available for study.

Morphology and principal component analysis

Seventeen meristic counts were recorded for all examined specimens under stereomicroscope (eight squamation characters and two dentition characters) or from X-rays (seven skeletal characters) as described in Barel et al. (1977) if not mentioned otherwise: abdominal vertebrae, caudal vertebrae (excluding the urostyle), total vertebrae (excluding the urostyle), dorsal fin spines, dorsal fin rays, anal fin spines, anal fin rays and series of scales on cheek. Number of scales along the horizontal line including the lower lateral line, number of scales on the upper lateral line and number of scales on the lower lateral line were counted as described in Dunz and Schliewen (2010). New or alternatively defined squamation counts are: (1) scales between edge of the postero-dorsal angle of the operculum to the anterior edge of the operculum where the preoperculum begins; (2) circumpeduncular scales on the level of the 4th pored scale of the lower lateral line (counted forward and starting with the posteriormost scale on caudal peduncle (1st scale), and excluding pored scales on the caudal fin); counted in a vertical alternating (zigzag) manner on the left side with midventral and middorsal scales counted as half scales; the total number of circumpeduncular scales around the caudal peduncle is then obtained by multiplying the obtained count by two; (3) scales between lateral line and dorsal fin origin as counted in a vertical alternating (zigzag) manner commencing below the insertion of the first dorsal spine down to the upper lateral line, but not including the pored lateral line scale; (4) scales below last dorsal spine and upper lateral line were counted in a vertical alternating (zigzag) manner starting from below the last dorsal spine insertion down to upper lateral line, but not including the lateral line pored scale; (5) lower jaw tooth rows (one outer and one or more inner) in lower jaw as counted from behind the anterior tip of lower jaws; and (6) upper jaw tooth rows as counted analogously to lower jaw tooth rows from behind the anterior tip of the premaxillae. Live colour notes are based on photographs of freshly wild caught fish (adults) as well as on live specimens kept in aquaria (first generation juveniles).

Distance measurements were taken for the species description, i.e. only for the type specimens and additional material of the new species, but not for the comparative material. Measurements follow Dunz & Schliewen (2010) except for caudal peduncle depth

which was measured on the level of the 4th scale of the lower lateral line (counted forward and starting with the posteriormost scale on caudal peduncle (1st scale), and excluding pored scales on the caudal fin). Measurements were taken point-to-point on the left side of specimens using a digital caliper with an accuracy of 0.01 mm and were rounded to the nearest 0.1 mm. Head measurements are given as percentage of the head length (HL), all remaining measurements are given as percentage of standard length (SL).

Principal component analyses (PCA) was performed for all 17 meristic counts of the total taxon set and subsequently of a reduced taxon set composed of the new species and the meristically closest species *Orthochromis stormsi* (Boulenger, 1902), *Haplochromis bakongo* Thys van den Audenaerde, 1964 were calculated using the statistical program PAST 2.17c (Hammer et al. 2001). Scores of most informative principal components PC1 and PC2 were visualized using bivariate plots, and variables contributing most to PC variation were identified using their loadings as tabulated.

Regarding the genus level taxonomy of haplochromine cichlids, we roughly follow the practice initiated by van Oijen et al. (1991) and van Oijen (1996), who included in *Haplochromis* all lacustrine taxa – hereby implicitly incorporation those genera, which comprise both, lacustrine and riverine members, i.e. *Ctenochromis* Pfeffer, 1893 and *Astatotilapia* Pellegrin, 1904 and *Thoracochromis* Greenwood, 1979. This practice has been extended to riverine haplochromines, e.g. by Wamunini Lunkayilakio & Vreven (2010). In accordance with the latter authors yet undescribed as well as the newly described species are herein referred to as *Haplochromis*, but in contrast to Wamuini Lunkayilakio & Vreven (2010) without quotation marks (see Discussion). For sake of simplicity, all *Orthochromis* species endemic to eastern affluents of Lake Tanganyika, i.e. from the Malagarasi, Luiche and Rugufu catchments are referred to as "Malagarasi-*Orthochromis*" in some parts of the text, tables and figures.

Results

Meristics

In the first PCA (all taxa included, Fig. 1A, Table 1), PC I explained 27.31 %, PC II 17.31 % and PC III 11.89 % of the total variance. Low PC I scores separated the five species *Orthochromis machadoi* (Poll, 1967), *O. stormsi*, *Haplochromis bakongo* and *H. vanheusdeni* spec. nov. from all other *Orthochromis*-like species, with the exception of the undescribed *H.* sp. "Kasinsha", which has intermediate scores. According to PC I loadings this separation is based mainly on low versus high counts of scales along the horizontal line, of the upper lateral line and number of total vertebrae (Table 1). PC II separates *O. stormsi*, *H. vanheusdeni* spec. nov., all Malagarasi basin *Or-*

thochromis and *O. polyacanthus* (Boulenger, 1899) from the remaining species including *H.* sp. "Kasinsha" except for *O. machadoi*, *O. torrenticola* and *H. bakongo*, whose scores are overlapping with the first group. Separation here is based mainly on scale counts on cheeks, dorsal fin spine number and scales between lateral line and dorsal fin origin. PC III (graph not shown) clearly separates *Schwetzochromis neodon* from all other specimens, according to PC III loadings (Table 1) mainly based on circumpeduncular scale counts. The second step PCA (Fig. 1B, Table 2) with those four species, which remained overlapping in the PC I / PC II bivariate plot separated *O. machadoi* on the basis of PC I scores from *H. vanheusdeni* spec. nov., *H. bakongo* and *O. stormsi*, mainly based on number of caudal vertebrae, scales on cheek and scales on the horizontal line (Table 2). Here PC I explained 29.35 % of variance, PC II 16.84 % and PC III 12.19 %. In summary, meristics alone allow diagnosing the new species against all analysed rheophilic haplochromine species, except for the *H. bakongo* and *O. stormsi*. We therefore differentially diagnose the new species based mainly on a combination of meristics, and we will use additional characters to separate it from *H. bakongo* and *H. stormsi*.

Taxonomy

Haplochromis vanheusdeni, spec. nov.
Figs 2–3, Table 3

Orthochromis sp. "Sonjo" – van Heusden, 2011

Holotype. CUMV 97639 (1, 70.7 mm SL), Tanzania, Morogoro state, drainage Rufiji, Sonjo River at bridge in Man'gula on road from Mikumi to Ifakara, altitude 302 m (–7.808231/36.896561), J. P. Friel, A. W. Thomson, T. R. Vigliotta, G. Kazumbe & S. Limbu, 28.IX.2007.

Paratypes. CUMV 93835 (13, 31.5–78.7 mm SL), collected with holotype. – ZSM 40703 (2, 50.3–58.7 mm SL), collected with holotype. – MRAC 34-09-P-001–003 (3, 54.0–58.3 mm SL), Tanzania, Morogoro state, drainage Rufiji, Sonjo stream at bridge on road Ifakara–Kidodi (–7.808339/36.896189), H. van Heusden, 2011. – ZSM 41440 (3, 56.2–63.6 mm SL),Tanzania, Morogoro state, drainage Rufiji, Sonjo stream at bridge on road Ifakara–Kidodi (–7.808339/36.896189), H. van Heusden, 2011. – ZSM 41559 (7, 47.2–67.8 mm SL), collected with MRAC 34-09-P-001–003. – ZSM 42308 (1, 83.9 mm SL), collected with holotype.

Additional material. CUMV 93833, 3, 31.5–60.4 mm SL; drainage Rufiji, Great Ruaha River at bridge in Kidatu on road from Mikumi to Ifakara (–7.66174/36.9773), J. P. Friel, A. W. Thomson, T. R. Vigliotta, G. Kazumbe & S. Limbu, 30.IX.2007. – CUMV 93834, 2, 36.6–56.2 mm SL; drainage Rufiji, Idete River at bridge in Idete on
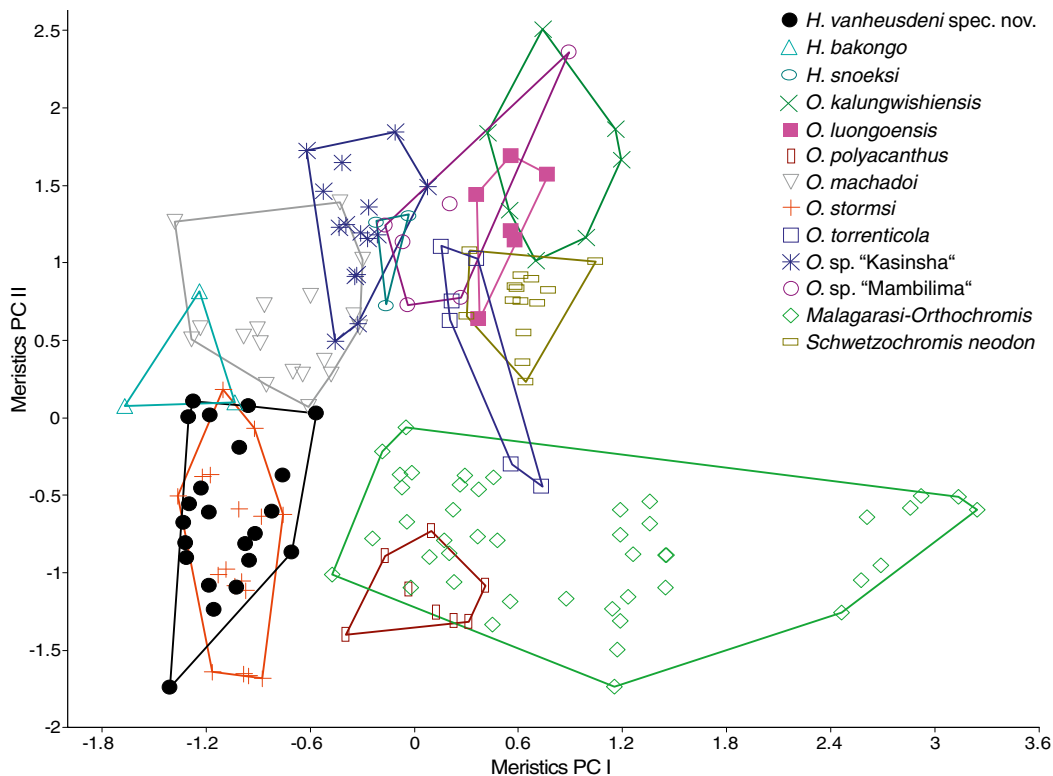
Fig. 1A. PCA scatter plot based on 17 meristic counts; species score limits visualized as convex hulls. PC I vs. PC II for all specimens (N = 169). PC I explains 50.03 % of the variance while PC II explains 12.79 %.

Table 1. Factor loadings of PC I–III for all investigated specimens (n = 169, see Fig. 1A). Highest loadings for each PC indicated in boldface.

| Meristics	PC I-III for all included fish		
	PC I	PC II	PC III
Scales on the cheek	−0.0660	**0.6760**	0.1651
Scales on operculum	−0.0304	0.2417	0.1509
Scales (horizontal line)	**0.4679**	0.2101	0.1580
Scales on the upper lateral line	**0.4357**	−0.0812	0.0181
Scales on the lower lateral line	0.1031	0.2526	−0.1304
Circumpeduncular scales	−0.0627	−0.1077	**0.5775**
Scales between lateral line and dorsal fin origin	−0.0173	**−0.3687**	−0.0306
Scales between last dorsal spine and upper lateral line	−0.0012	−0.0024	0.0100
Inner series of teeth in upper jaw	0.2114	−0.0430	**−0.3951**
Inner series of teeth in lower jaw	0.1790	−0.0638	**−0.3939**
Abdominal vertebrae	0.1904	−0.0719	0.0549
Caudal vertebrae	0.2805	0.1805	0.0715
Total vertebrae	**0.4732**	0.1045	0.1236
Anal fin spines	0.0016	0.0108	0.0142
Anal fin rays	0.2170	−0.1302	−0.1331
Dorsal fin spines	0.3163	**−0.3347**	0.3371
Dorsal fin rays	0.0917	0.1974	−0.3268
Eigenvalue	13.2340	3.3826	2.9394
% variance	50.0340	12.7890	11.1130
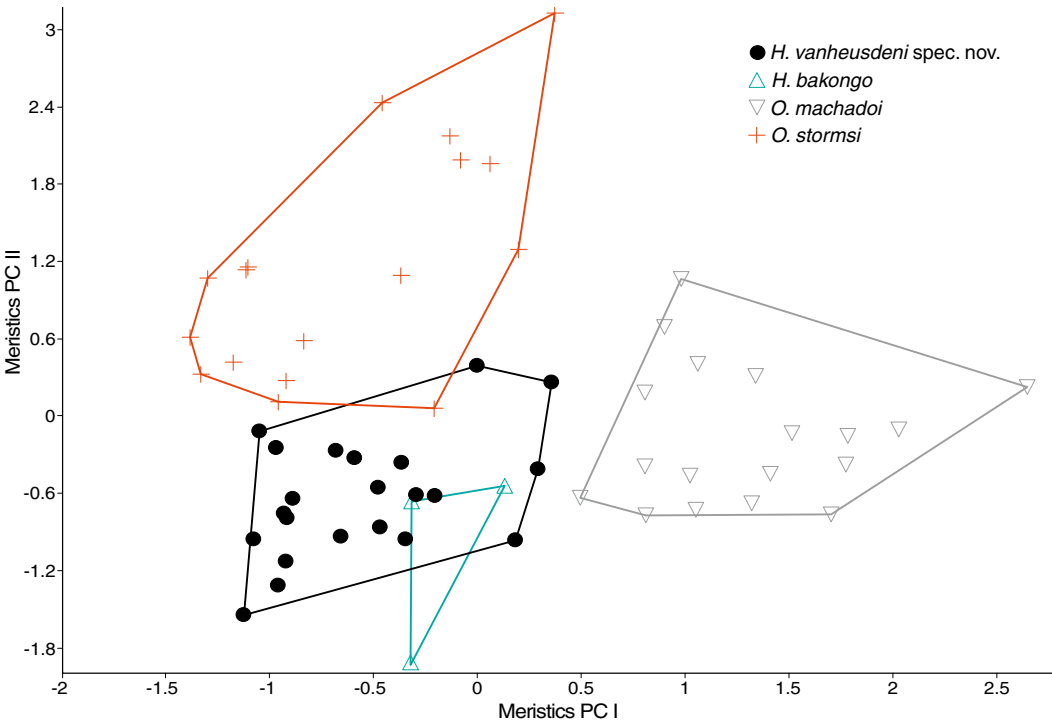
Fig. 1B. PCA scatter plot based on 17 meristic counts; species score limits visualized as convex hulls. PC I vs. PC II for a reduced taxon set composed of *Haplochromis vanheusdeni* spec. nov. and the meristically three closest species. PC I explains 29.35 % of the variance while PC II explains 16.84 %.

Table 2. Factor loadings of PC I–III for investigated specimens of *Haplochromis bakongo*, *Orthochromis machadoi*, *O. stormsi* and the *Haplochromis vanheusdeni* spec. nov. (n=60, see Fig. 1B). Highest loadings for each PC indicated in boldface.

Meristics	PC I–III for the four species		
	PC I	PC II	PC III
Scales on the cheek	**0.6476**	**0.3732**	0.0073
Scales on operculum	0.2840	**0.2273**	**0.3108**
Scales (horizontal line)	**0.3614**	−0.1176	**0.3313**
Scales on the upper lateral line	−0.0619	0.0584	−0.1775
Scales on the lower lateral line	−0.1166	0.0861	**0.7871**
Circumpeduncular scales	0.0140	−0.0207	−0.0153
Scales between lateral line and dorsal fin origin	−0.2213	**0.7931**	−0.0319
Scales between last dorsal spine and upper lateral line	0.0000	0.0000	0.0000
Inner series of teeth in upper jaw	0.1354	0.1048	−0.1707
Inner series of teeth in lower jaw	0.0928	0.1957	−0.2245
Abdominal vertebrae	−0.1143	0.0015	0.0826
Caudal vertebrae	**0.3531**	−0.1873	−0.0704
Total vertebrae	0.2286	−0.191	−0.0044
Anal fin spines	0.0095	0.0135	−0.0014
Anal fin rays	0.2654	−0.0106	−0.1813
Dorsal fin spines	−0.0650	0.1248	−0.0300
Dorsal fin rays	0.1046	0.1353	−0.1275
Eigenvalue	3.0790	1.7670	1.2794
% variance	29.3460	16.8410	12.1940

Table 3. Measurements & counts for holotype and paratypes of *Haplochromis vanheusdeni* spec. nov. and four additional specimens caught in the Great Ruaha (CUMV 93833) and Idete River (CUMV 93834).

| Measurements	holotype	holotype + paratypes				CUMV 93833		CUMV 93834	
		min	max	SD	n	Ind. 1	Ind. 2	Ind. 1	Ind. 2
Total length (mm)	87.9	40.8	101.2		30	71.6	62.6	70.0	56.2
Standard length SL (mm)	70.7	33.2	83.9		30	60.4	53.1	45.9	36.6
Head length HL (mm)	23.7	10.3	27.6		30	20.9	17.7	19.8	12.4
% HL									
Interorbital width	20.3	14.2	21.0	1.8	18	17.0	17.9	15.5	15.7
Preorbital width	34.2	26.3	35.1	2.2	18	30.4	30.5	28.0	25.0
Horizontal eye length	23.2	19.6	24.9	1.3	18	19.5	18.2	20.7	23.5
Snout length	38.4	26.2	41.1	3.5	18	33.1	36.8	39.1	28.5
Internostril distance	21.9	15.3	23.6	2.5	18	16.7	19.8	18.1	14.9
Cheek depth	30.8	18.2	31.4	3.6	18	26.9	28.7	27.3	20.2
Upper lip length	31.7	20.3	34.8	3.4	18	27.8	27.2	26.5	21.0
Lower lip length	33.8	21.7	33.8	2.9	18	27.6	27.6	28.3	23.9
Lower lip width	40.1	25.4	42.0	4.7	18	35.1	31.9	34.5	25.0
Lower jaw length	33.3	32.6	40.0	2.1	18	37.3	40.0	40.0	32.4
% SL									
Predorsal distance	35.5	33.8	39.3	1.5	18	34.0	35.9	37.6	33.8
Dorsal fin base length	57.7	47.9	57.7	2.4	18	54.4	55.1	52.7	54.1
Last dorsal fin spine length	11.3	9.4	13.2	1.0	18	12.6	12.3	13.6	11.9
Anal fin base length	19.8	16.4	19.9	1.1	18	18.5	19.9	19.0	18.2
Third anal fin spine length	10.0	9.4	13.2	1.1	18	12.2	12.1	12.8	12.5
Pelvic fin length	23.1	21.3	27.9	2.0	18	20.3	20.8	24.6	23.8
Pectoral fin length	20.7	19.0	24.2	1.3	18	18.8	19.5	23.6	22.8
Caudal peduncle depth	13.2	10.2	13.2	0.6	18	12.4	11.1	11.7	11.7
Caudal peduncle length	15.6	13.7	20.5	1.6	18	17.8	17.6	18.6	16.5
Body depth (pelvic fin base)	28.6	23.9	29.1	1.3	18	27.4	27.8	27.5	23.2
Preanal length	60.5	56.0	61.6	1.3	18	61.8	58.1	61.8	56.8
Anus-anal fin base distance	5.4	4.1	6.1	0.6	18	3.5	3.6	3.4	3.1
Counts									
Dorsal fin spines	17	16 (8); 17 (10)			18	17	17	17	17
Dorsal fin rays	8	8 (5); 9 (12); 10 (1)			18	9	9	8	9
Anal fin spines	3	3 (18)			18	3	3	3	3
Anal fin rays	6	6 (2); 7 (15); 8 (1)			18	7	7	7	7
Pelvic fin spines	1	1 (18)			18	1	1	1	1
Pelvic fin rays	5	5 (18)			18	5	5	5	5
Pectoral fin rays	15	14 (1); 15 (17)			18	15	15	15	15
Scales (horizontal line)	28	25 (1); 27 (8); 28 (9)			18	28	27	29	28
Upper lateral line	20	19 (1); 20 (8); 21 (8); 22 (1)			18	20	21	20	21
Lower lateral line	10	6 (1); 8 (2); 9 (5); 10 (8); 11 (1); 12 (1)			18	10	10	10	11
Circumpeducular	16	14 (4); 16 (14)			18	16	16	16	16
Abdominal vertebrae	14	13 (4); 14 (14)			18	14	14	14	14
Caudal vertebrae	14	14 (9); 15 (9)			18	15	15	15	16
Total number of vertebrae	28	28 (12); 29 (5)			18	29	29	29	30
Teeth in upper outer row	35	30 (2); 31 (2); 32 (3); 33 (2); 34 (1); 35 (4); 36 (2); 37 (1); 38 (1)			18	36	32	35	33
Teeth in lower outer row	20	14 (1); 15 (1); 16 (1); 17 (1); 18 (1); 19 (2); 20 (2); 21 (3); 23 (1); 24 (3); 25 (1); 26 (1)			18	20	20	21	18
Gill rakers (lower)	6	5 (1); 6 (11); 7 (6)			18	7	8	7	6
Gill rakers (upper)	3	3 (18)			18	3	3	3	3
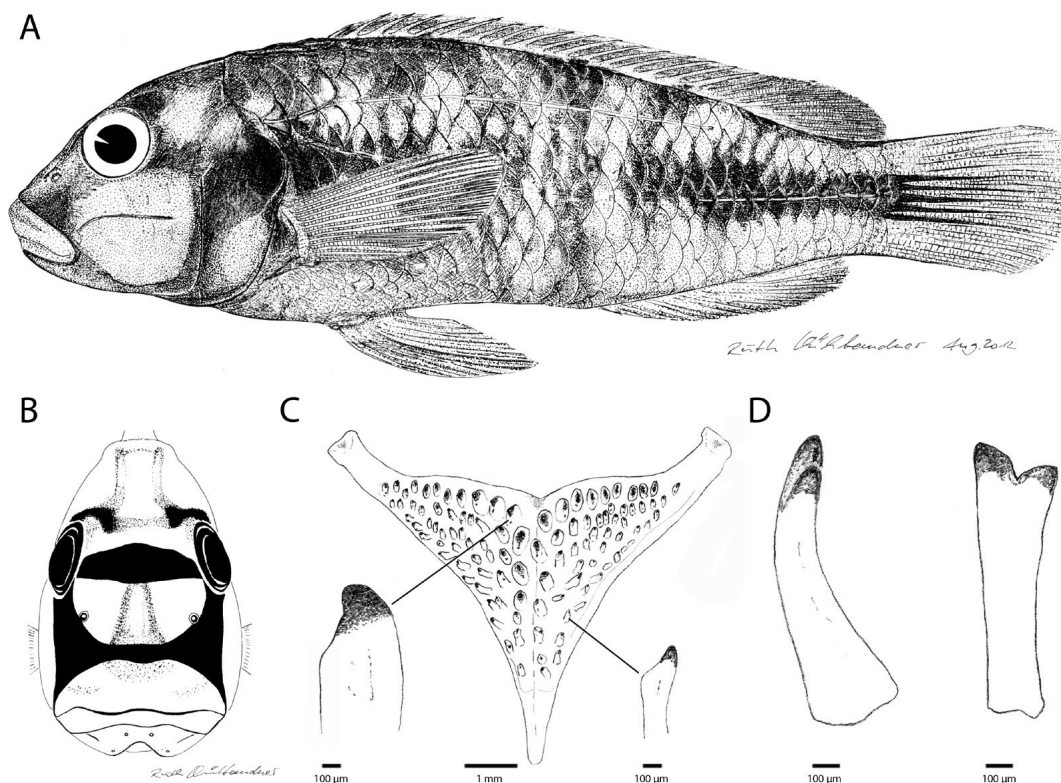
Fig. 2. *Haplochromis vanheusdeni* spec. nov. **A.** Holotype (drawing Ruth Kühbandner); **B.** frontal view of the head (drawing Ruth Kühbandner); **C.** lower pharyngeal bone and two different pharyngeal teeth of specimen ZSM 41559 DRC-2011/1047, 67.8 mm SL (drawing F. Schedel); **D.** bicuspid frontal tooth of outer row in upper jaw of specimen ZSM 40703 (Specimen: 2, 50.3 mm SL) lateral and frontal view (drawing F. Schedel).

road from Ifakara to Taveta (–8.10391/36.4881), J. P. Friel, A. W. Thomson, T. R. Vigliotta, G. Kazumbe & S. Limbu, 29.IX.2007.

Differential diagnosis. *Haplochromis vanheusdeni* spec. nov. can be distinguished from all currently valid species of the genus *Orthochromis* (sensu de Vos & Seegers, 1998) except *O. torrenticola* and from the three undescribed species *O.* sp. "Igamba", *O.* sp. "Kasinsha", *O.* sp. "Mambilima" by the presence of egg spots on the anal fin in both males and females (vs. no egg spots), and by hypuralia 1 and 2 and hypuralia 3 and 4 either clearly separated or separated by a clearly visible seam (vs. never fused into a single seamless unit). In the species by species comparison, *Haplochromis vanheusdeni* spec. nov. can be distinguished from *O. kalungwishiensis*, *O. kasuluensis*, *O. luongoensis* and *O. torrenticola* by having fewer caudal vertebrae (14–16 vs. 17) and fewer total vertebrae (28–30 vs. 31–33); from *O. rugufuensis* and *O. uvinzae* by having fewer total vertebrae (28–30 vs.

31–33) and dorsal fin spines (16–17 vs. 19–20); from *O. polyacanthus* and *O. rubrolablialis* by having fewer inner series of teeth in the lower jaw (1–2 vs. 3–5) and fewer dorsal fin spines (16–17 vs. 18–20); and from *O. malagaraziensis* by having more scales between the lateral line and the dorsal fin origin (3–4 vs. 5–6); from *O. machadoi*, *O. mazimeroensis*, *O. stormsi*, *H. bakongo* by having a scaleless chest (vs. a scaled chest); from *O. mosoensis* by having small cycloid scales on the belly (vs. no scales); from *O. luichensis* by the different stripe and bar patterns on the head (for more information and comparison see please De Vos & Seegers 1998); from *Schwetzochromis neodon* by the presence of lachrymal stripes (see Roberts & Kullander 1994) and fewer inner teeth rows in both jaws (1–3 vs. 4–6); from *Haplochromis snoeksi* by having fewer scales on the horizontal line (26–29 vs. 30–31) and on upper lateral line (20–22 vs. 23) and in having fewer caudal vertebrae (14–16 vs. 17).
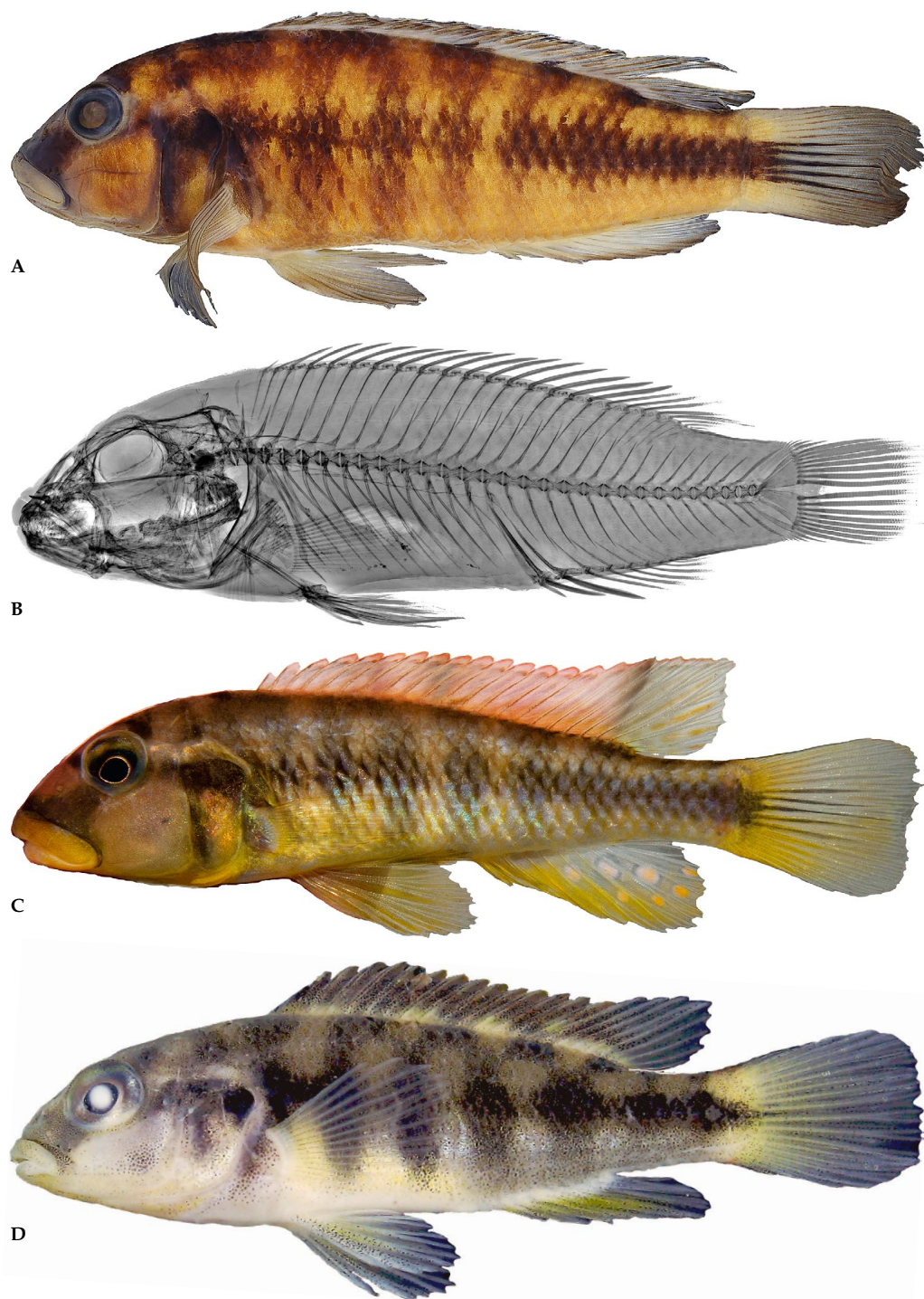
Fig. 3. *Haplochromis vanheusdeni* spec. nov. **A.** Holotype, CUMV 97639, 70.7 mm SL; Tanzania, Sonjo River; **B.** radiograph of holotype; **C.** young male, alive, not preserved (note the ocellated egg spots in anal fin; photograph H. van Heusden); **D.** captive raised F1 juvenile, not preserved, 19.5 mm SL.
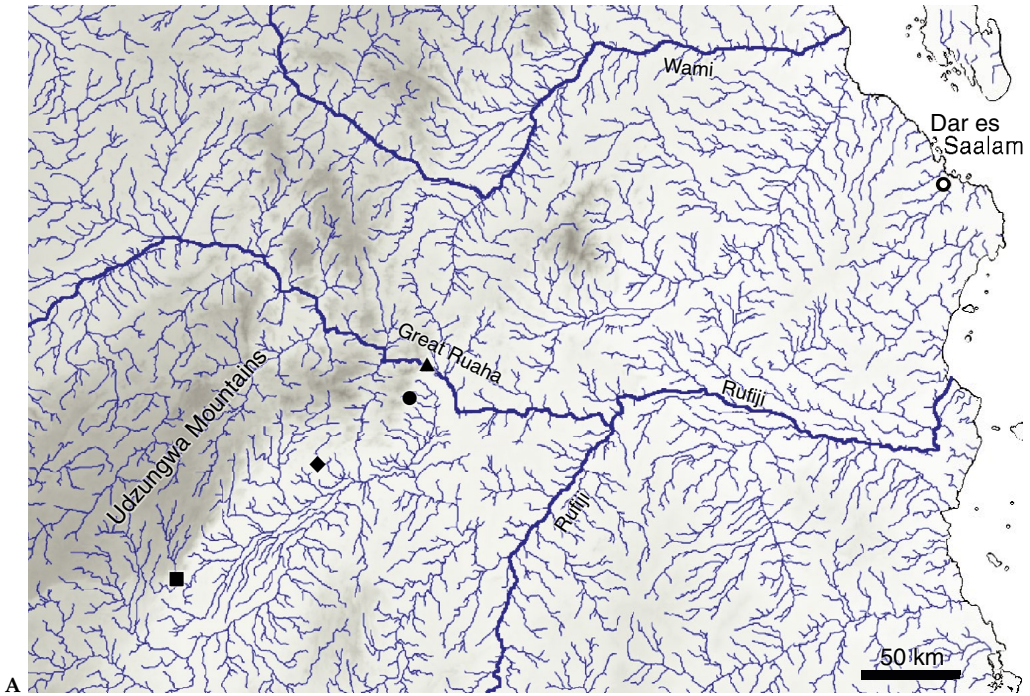
Fig. 4. Distribution and habitat of *Haplochromis vanheusdeni* spec. nov. **A.** Map of the Udzungwa Mountains region, Tanzania. Symbols designate collection points: Sonjo River (dot, type locality); Great Ruaha River (triangle), Idete River (diamond) and Kihansi River (square). Map based on USGS HydroSHEDS (Lehner et al. 2008). **B.** Type locality, Sonjo stream, upstream view from bridge of Mikumi–Ifakara road (December 2011, photo H. van Heusden).

Description

Meristics and morphometric characters are based on type material and four additional specimens. Values and their ranges are presented on Table 3. For general appearance see Figs 2–3. Maximum length of a wild caught specimens 83.9 mm SL. A moderately elongate species with maximum body depth close to insertion of first dorsal spine. Caudal peduncle rather short but always longer than deep (ratio of caudal peduncle length to depth: 1.13–1.78). Head length about one third of the standard length. Dorsal head profile straight between upper lip and eye region, then becoming gently curved towards dorsal fin origin. No prominent nuchal gibbosity. Eye diameter larger than or rarely equal to interorbital width. Jaws slightly retrognathous. Posterior tip of maxilla reaching slightly beyond anterior margin of orbit. Lips well developed, upper lips becoming thinner posteriorly. Two separate lateral lines.

Squamation. Flanks above and below the lateral lines covered with comparatively large ctenoid scales, except for cycloid scales of the anterior dorsal and lowermost ventral area. Belly with very small cycloid scales. Chest scaleless; chest to flank transition with small, deeply embedded cycloid scales. Snout up to eye level scaleless, nape and occipital region with medium sized cycloid scales, interorbital scales deeply embedded. Cheeks devoid of large, externally visible scales, but small deeply embedded cycloid scales may be present. Cycloid scales on operculum of variable size (minute to medium sized) and shape (ovoid to circular); opercular blotch partially covered with medium sized scales, but posterior margin always scaleless.

Upper lateral line scales 19–22 and lower lateral line 6–12. Horizontal line scales 25–28 plus no or one pored scale on caudal fin. Upper and lower lateral lines separated by two scales. At level of last dorsal fin spine on large ctenoid scale below one small dorso-ventrally compressed cycloid scale. Anterior part of the caudal fin covered with 3–4 columns of small cycloid scales, with median scales being slightly larger; scaled area of caudal fin caudally extended at upper and lower area with minute, interradial scales. Scales around caudal peduncle 14–16.

Jaws and dentition. Anterior jaw teeth (Fig. 2D) of outer rows of upper and lower jaw large, closely set and bicuspid or subequally bicuspid; posterior teeth more widely set caudally becoming unicuspid and smaller. Brownish crown of single bicuspid teeth slightly expanded, with uncompressed, narrowly set cusps; neck of the bicuspid teeth stout (Fig. 2D). Tooth counts of outer row of upper jaw between 30–38 and of outer row of lower jaw 14–26. Larger specimens generally with more teeth. Two (rarely one) inner upper and lower jaw teeth rows with small and tricuspid, rarely bicuspid or unicuspid teeth.

Lower pharyngeal bone (Fig. 2C) of the single dissected paratype (ex ZSM 41559, 67.8 mm SL) about 1.5 times broader than long with a short anterior keel (about 0.4 times of the toothed area) (Fig. 2C). Dentigerous triangular surface of lower pharyngeal bone about 1.5 times broader than long, with 10+10 teeth along posterior margin and seven teeth along midline. Posterior row and midline teeth (Fig. 2C) larger than lateral teeth (Fig. 2C). Pharyngeal teeth weakly bicuspid; posterior row teeth enlarged compared with more slender, bevelled anterior teeth.

Gill rakers. Total gill raker count 8–10, with two epibranchial, one angle, and five to seven ceratobranchial rakers which increase in size caudally. One non-type specimen (CUMV 93833, specimen: 2, 53.1 mm SL, Great Ruaha River) with eight creatobranchial gill rakers. Epibranchial gill rakers thinner than angle and creatobranchial rakers. Inner surface of gill rakers with clearly visible microbranchiospines.

Fins. Dorsal fin with 16–18 spines and with 8–10 rays. First dorsal fin spine always shortest. Dorsal fin base length between 49.3–57.7 % SL. Posterior end of the dorsal fin rays extending slightly beyond caudal fin base; posterior tip of anal fin ending slightly before or at caudal fin (if undamaged), caudal fin outline subtruncate to truncate. Anal fin with 3 spines with 3rd spine longest and 6–8 rays. Anal fin base length between 16.4–19.8 % SL. Pectoral fin with 15 or rarely 14 rays. Pectoral fin length between 19.0–24.0 % SL; longest pectoral ray not reaching level of anus. First upper and lower pectoral fin rays very short to short, especially first upper ray hardly recognizable. Pelvic fin with 1st spine thickly covered with skin and 5 rays. Pelvic fin base always behind pectoral fin base. Longest pelvic fin ray reaching or slightly exceeding anus in some paratypes.

Vertebrae and caudal fin skeleton (Fig. 3B). 28–29 total vertebrae (excluding the urostyle element), with 13–14 and 14–15 abdominal and caudal elements, respectively. Hypuralia 1 and 2 and hypuralia 3 and 4 either clearly separated (hypuralia 1 and 2 in holotype and some paratypes) or separated by a clearly visible seam (hypuralia 1 and 2 in several paratypes, always in hypuralia 3 and 4), but never fused into a single seamless unit.

Coloration in life (based on field photographs of adult specimens). (Fig. 3C). Body ground coloration pale brown to grey; back, flanks and caudal peduncle towards chest and belly light beige to yellowish. Dorsal head surface brownish-grey, cheeks greyish, especially the lower part. Ventral side of head beige. Branchiostegal membrane beige to

yellowish. Operculum yellow-orange to brownish with a black opercular spot extending rostrally as a broad dark grey-brown stripe almost to the posterior edge of the eyes. Another grey element, an oblique bar, originating from the opercular spot crossing the preoperculum and operculum finally reaching to the ventral margin of the opercular complex. Turquoise hues around pectoral fin base and between preoperculum and operculum. A dark grey lachrymal stripe, gradually extending and widening from its origin at the anterior-ventral margin of the orbit to before the edges of the nostrils and almost reaching the upper lip margin. Across snout above upper lip margin lachrymal stripes of both sides fusing, resulting in a U-shaped frontal face mask. Supraorbital stripes starting from rear dorsal orbit margins towards dorsal fin origin but deviating after a short distance anteriorly where both stripes at the forehead fuse centrally and form a flattened "M" in the rostral view (see Fig. 2B). No nostril stripe present. Dark grey interorbital stripe present. A dark greyish and less distinctive nape band connected with the first vertical stripe above the operculum. Upper and lower lips brownish-grey, rostrally bright yellow, caudally orange, and lower lip lighter coloured than upper lip. A greyish mid lateral band starting from the opercular blotch to the caudal fin, becoming more distinctively edged on caudal peduncle; this band further extending onto the scaled part of the caudal fin (approximately two thirds of caudal fin), where splitting into three to five horizontal streaks on the caudal fin membranes. Mid lateral stripe crossed by (6–7) greyish bars, sometimes Y-shaped and sometimes extending into the dorsal fin. Dorsal fin ground coloration a mixture of whitish and black elements. Dorsal fin membrane margins orange, followed submarginally by first a white and then black element. Some specimens with orange dots in soft rayed portion of dorsal fin, similar but smaller and less well defined as the egg spots in anal fin (see below). Anal fin yellow-greenish, anteriorly and towards the margins of the anal fin yellow. One to four, in large tank-raised males up to 10, orange egg spots (large orange centre, followed by white concentric ring, which is surrounded by a more or less ill-defined clear concentric ring; wild-caught and tank-raised females never with more than two egg spots (van Heusden 2011, pers. obs.). Egg spots located on the posterior two thirds of the upper anal fin, here centred between anal rays. Caudal fin yellowish-greyish towards base of caudal fin orange, above and below the extensions of the mid lateral band brownish to orange. Outer caudal fin rays with black margin. Pectoral and pelvic fin greyish to brownish.

Juvenile coloration in life (based on photos of tank-raised juveniles approx. 20 mm SL; six weeks after fertilization). Beige to greyish body ground coloration, silvery towards the belly and chest. Patterns of stripes on head are as described for adults. Mid lateral band visible but less distinct as compared to adults, with only a weak extension onto caudal fins. Y-shaped vertical stripes connected above the upper lateral line, thereby forming a web-like pattern. Dorsal fin hyaline except for few orange spots on membranes. Anal, caudal, pelvic and pectoral fins hyaline, no defined egg spot discernible on anal fin.

Coloration in alcohol (Fig. 3A,D). Overall comparable to live specimens, but due to preservation with different colours: overall body ground coloration beige or brownish in older material chest and belly lighter and beige. Branchiostegal membrane beige and or whitish. Upper lip light grey, lower lip whitish. Dark brown or grey stripes on head and the mid lateral band dark brown on flanks and caudal peduncle as the vertical bars crossing the mid lateral band. Dorsal fin beige or greyish and greyish with some black streaks on the membrane between the rays; black spots near the tips of the membranes between the spines and rays (excluding the last 2–4 rays) of the dorsal fin. Tips of dorsal fin membranes whitish. Anal fin beige to light grey, in most specimens with a dark brown to greyish margin. No egg spots visible on anal fin of preserved specimens. Caudal fin beige or greyish, with a black margin on rear part of fin. Pectoral and pelvic fin beige or light grey.

Distribution and biology. *Haplochromis vanheusdeni* spec. nov. is known from four localities in the Morogoro region (Tanzania), i. e. three comparatively small streams of the Great Ruaha basin (Sonjo, Idete, Kihansi) draining the eastern flanks of the Udzungwa mountains, as well as from one stretch of the main Great Ruaha River (Fig. 4A). At the type locality, Sonjo stream is rocky with sandy patches, about 4.5 m wide and in average 50 cm deep (Fig. 4B), measured water temperature was 22 °C and had an pH 8.1 in December 2010 (van Heusden 2011, and pers. comm. 2013). The new species is a benthic-rheophilic fish, mostly found among stones over sand and debris in smaller streams or larger rivers. Stomach contents were not investigated, but underwater observations suggest a mixed diet of sand-and-debris dwelling organisms and drifting food particles. It was sometimes observed in larger groups (up to 10 individuals per square meter), but large males and brood-caring females defend small territories, sometimes centred around a whole under stones (van Heusden 2011). *Haplochromis vanheusdeni* spec. nov. is a maternal

mouthbrooder. Aquarium observations suggest that males actively excavate holes under stones, which are used as mating sites. Females in captivity spawned between 20 to 40 eggs (diameter is approx. 2 mm). In Sonjo stream *Haplochromis vanheusdeni* spec. nov. is found together with Kneriidae (*Parakneria* sp. "Udzungwa"), Amphiliidae (*Amphilius* spp.), Mochokidae (*Chiloglanis* sp.), Cyprinidae ('*Barbus*' sp., *Labeo* sp.), Poeciliidae (*Lacustricola* sp.) and another haplochromine cichlid (*Haplochromis* cf. *bloyeti*), the latter missing in the Kihansi River (van Heusden 2011, and pers. obs. JPF 2009).

Etymology. The species name *vanheusdeni* honours the Dutchman Hans van Heusden, one of the most dedicated cichlid naturalists, who has documented for the first time with underwater photographs and videos as well as with aquarium observations the behaviour and ecology of the new species and many other cichlids all over Africa.

Discussion

Generic placement and affinities. The new species superficially resembles *Orthochromis* and fits the latest generic diagnosis in seven out of ten morphological characters compiled from De Vos & Seegers (1998): (1) rather slender body; (2) eyes generally superolateral in position, giving the fish a goby like appearance; (3) scales on the sides mainly ctenoid and, if present, cycloid and minute on chest and belly, often deeply imbedded in the skin; (4) a remarkably abrupt size change between the large ventrolateral scales of the flanks and the small scales of the chest and belly. Chest and belly scaleless in some species. Absence or extensive reduction of cheek squamation; (5) increased number of spinous rays in the dorsal fin (without a corresponding reduction in the number of branched rays); (6) elongated second or second and third branched rays in the pelvic fin; (7) outer row of both jaws with unequally bicuspid teeth. Often a few teeth in the corners are unicuspid but there is no tendency for a conical or spatulate shape of the cusps in the larger specimens, as is often the case in other haplochromines. Inner teeth of upper lower jaws tricuspid or partly unicuspid and arranged into 2–4 rows. However, the new species differs from the *Orthochromis* diagnosis in the following three characters states given by De Vos & Seegers (1998): (1) Dorsal head profile is not decurved with a strongly sloping preorbital skull profile, but rather straight and shallow; (2) hypurals 1 and 2, and 2 and 4 of the caudal fin skeleton are not fused, but fully separated or separated by a clearly discernible suture; and (3) they are mouthbrooders with "true" (ocellated) egg spots as shown in the genus

Haplochromis sensu lato. The new species differs from the highly derived, but superficially similarly single member of the rheophilic genus *Schwetzochromis* by a number of characters, although both taxa share the presence of large egg spots on the anal fin in both sexes. According to the most recent diagnosis of *Schwetzochroms* by De Vos & Seegers (1998) the new species differs from *S. neodon* in (1) lacking sharply contrasting longitudinal stripes; in (2) the presence of lachrymal stripes across the snout; in (3) lacking long elongate pelvic fins in males; in (4) only 2 and not 4–6 inner tooth rows; in (5) having a clearly defined single row of large out teeth in the lower jaw and not a broad band of teeth; and in (6) having bicuspid non-spatulate teeth instead of unicuspid, slender or broad-tipped spatulate teeth. Based on these discrepancies, we could have redefined *Orthochromis* or *Schwetzochromis* in order to incorporate the new rheophilic species. However, published and unpublished molecular data (e. g. Koblmüller et al. 2008, Schwarzer et al. 2011, Schliewen et al. unpubl.) in combination with our own meristic analysis (overview see Fig. 1A) strongly suggest that *Orthochromis* as currently defined is not monophyletic, and that *Haplochromis vanheusdeni* spec. nov. is generical distinct from all Malagarasi-*Orthochromis*, i. e. the meristically rather uniform *Orthochromis* subgroup that contains the type species *O. malagaraziensis*. A full appraisal of haplochromine relationships and their genus-level taxonomy based on nuclear and mitochondrial molecular as well as morphological data is underway (Schedel & Schliewen in prep.), but not yet available. Therefore we have chosen to place the new species in the meantime in the catch-all genus *Haplochromis* Hilgendorf, 1888. We could have placed the new species also in "*Haplochromis*" (with quotation marks), in order to testify that this placement is preliminary and that *Haplochromis* is clearly not monophyletic. Although we (UKS) have adopted the use of genus names in quotation marks in earlier publications, we now avoid the use of quotation marks with a valid taxon name in a new description, as the ICZN code does not recognize such notation, and new species binomials do need to include a valid genus name starting with an upper-case letter, and typographical signs do not form a part of the name of a taxon (ICZN 1999; Articles 5.1 and 5.3).

Conservation. *H. vanheusdeni* spec. nov. appears endemic to rivers draining the eastern slope of the Udzungwa-mountains, which are famous for their high level of endemism in both plants and animals. The Udzungwa mountains are part of the Eastern Arc Mountains, a chain of thirteen separate mountain blocks, which are hypothesized to have enjoyed a comparatively stable and wet climatic regime over

large geological time scales (Lovett 1993). This stability is reflected by the high degree of endemism, both in plants and animals e.g. (Lovett & Wasser 1993. Approximately 100 endemic vertebrate species have been described, and some endemic lineages are estimated to have diverged back in the early Miocene during times, when there was a continuous forest cover from the Congo basin to East Africa (Burgess et al. 2007). However, surprisingly few endemic fish lineages are known from this region, and, with regard to haplochromine cichlids, only *Ctenochromis pectoralis* Pfeffer, 1893 represents a comparatively ancient lineage (Koblmüller et al. 2008). This taxon is endemic to the Kilimandjaro-Usambara region, i. e. to the northeastern range of the Eastern Arc Mountains. Our preliminary mitochondrial DNA data (Schliewen et al. unpubl.) suggest that *H. vanheusdeni* spec. nov. is the single representative of another comparatively ancient lineage in the region, and the high degree of yet undescribed fish species from the same streams, where *H. vanheusdeni* spec. nov. occurs, i. e. *Parakneria* sp. "Udzungwa" (Seegers 1985) and multiple undescribed species from several fish genera (JPF & UKS pers. obs.) suggests, that *H. vanheusdeni* is not the only locally endemic species there. These results show, that a thorough investigation of all mountainous streams from the Easter Arc Mountains would likely result in the discovery of substantially more endemic fish species, possibly not only from the Great Ruaha drainage. It further suggests that the current aquatic ecoregion delineation of Thieme et al. (2005) is not be sufficiently fine-scaled to differentiate important areas of aquatic endemism in the area, because those do not differentiate between mountainous and lowland catchments. Such a fine-scaled delineation is important for conservation planning. The Udzungwa National Park, for example, does not include areas now known for occurrence of the locally endemic *H. vanheusdeni* spec. nov.

Appendix. Comparative material examined

Haplochromis bakongo Thys van den Audenaerde, 1964: MRAC 142002, 1, holotype, 74.7 mm SL; Democratic Republic of Congo, Ngombe River at Banza Mfinda, Lower Congo, no GPS data available. – ZSM 37741, 2, 41.9–46.1 mm SL; Democratic Republic of Congo, drainage Kwilu, small stream approximate 45 min north of Yabi station on Jules van Lancker farm (–5.5901/14.7514).

Haplochromis snoeksi Wamuini Lunkayilakio & Vreven, 2010: MRAC A7-009-P-0001, 1, holotype, 82.5 mm SL; Democratic Republic of the Congo, River Ngeba/Ngufu, village Ngeba, affluent of the River Inkisi, Lower Congo (–5.1838/15.2064). – MRAC A7-009-P-0004, 1, paratype, 93.8 mm SL; Democratic Republic of the Congo, River Ngeba/Ngufu, village Ngeba, affluent of the River Inkisi, Lower Congo (–5.1838/15.2064). – MRAC A9-014-P-0001, 1, paratype, 81.2 mm SL; Democratic Republic of the Congo, River Ngeba, village Ngeba, affluent of the River Inkisi, at Kimasi bridge, Lower Congo (–5.1838/15.2064).

Orthochromis kalungwishiensis (Greenwood & Kullander, 1994): ZSM 41427, 1, 79.2 mm SL; Zambia, Kalungwishi stream above Lumanmgwe falls on the road Mukunsa–Kawambwa (–9.5431/29.3878). – ZSM 41431, 6, 44.4–75.8 mm SL; Zambia, Kalungwishi stream above Lumanmgwe falls on the road Mukunsa–Kawambwa (–9.5431/29.3878).

Orthochromis kasuluensis De Vos & Seegers, 1998: ZSM 41455, 5, 48.2–67.0 mm SL; Tanzania, Ruchugi River east of Kasulu on road to Kasulu–Kibondo (–4.5347/30.1483).

Orthochromis luichensis De Vos & Seegers, 1998: ZSM 41445, 7, 38.0–72.7 mm SL; Tanzania, Mkuti River road bridge east of Kandihwa village (–4.8867/29.8703).

Orthochromis luongoensis (Greenwood & Kullander, 1994): CU 91747, 1, 69.9 mm SL; Zambia, Lufubu River falls below bridge at Chipili on Mansa–Munuga road, (–10.7286/29.0936). – ZSM 41437, 6, 46.3–68.4 mm SL; Zambia, Luongo stream at bridge on road Mwenga–Kashiba affluent to Lake Mweru / Upper Congo basin (–10.4708/29.0261).

Orthochromis machadoi (Poll, 1967): BMNH 1984.2.6. 104–108, 5, 42.31–52.1 mm SL; Angola, Cunene River (–17.267/14.50). – BMNH 1984.2.6.109, 1, 44.7 mm SL; Angola, Cunene River (–17.05/13.5). – BMNH 1984.2. 6.113, 1, 52.2 mm SL; Angola, Cunene River (–17/13.25). – BMNH 1984.2.6.116-131, 4 out of 22, 50.5–60.1 mm SL; Angola, Cunene River (–16.983333/13.366667). – BMNH 1984.2.6.132–141, 3, 43.4–55.4 mm SL, Angola, Cunene River (–14.383333/15.300000). – BMNH 1984.2.6.142–145, 4, 50.3–65.7 mm SL; Angola, Cunene River (–14.916667/15.100000).

Orthochromis malagaraziensis David, 1937: ZSM 41469, 2, 66.5–68.8 mm SL; Tanzania, Malagarasi River close to Uvinza (–5.1183/30.3825).

Orthochromis polyacanthus (Boulenger, 1899): MKB 18, 5, 60.1–66.4 mm SL; drainage Lake Mweru, no further information available. – MKL 11, 2, 51.1–65.1 mm SL; no further information available. – MKL 12, 1, 63.5 mm SL; no further information available.

Orthochromis rubrolabialis De Vos & Seegers, 1998: ZSM 41463, 8, 44.5–86.7 mm SL; Tanzania, Malagarasi River close to Uvinza (–5.1183/30.38).

Orthochromis stormsi (Boulenger, 1902): MRAC 96-031-P-1303–1307, 5, 38.5–64.5 mm SL; Democratic Republic of the Congo, Lualaba River chutes 47 km on road of Kisangani–Lubutu near of the Concasserie, no GPS data available. – ZSM 32393, 5 out of 6, 40.0–65.6 mm SL; Republic of Congo, Congo main channel near Djoue River confluence at "Les rapides" (–4.31306/15.2289). – ZSM 37603, 1, 44.8 mm SL; Democratic Republic of the Congo, Lubuya stream below bridge on Lubutu road, close to Wanie Rukula (0.1928/25.5319). – ZSM 37541, 3, 63.5–80.3 mm SL; Democratic Republic of the Congo, Kisangani market, bought from woman who sells fishes from Wagenia rapids or fishes bought directly at Wagenia village (0.4939/25.2072). – ZSM 38129, 3, 52.5–88.0 mm SL; Democratic Republic of the Congo, Congo River, obtained from local fishermen at Kinsuka rapids, exact collecting location unclear (–4.3278/15.2306). – ZSM 38337, 1, 52.8 mm SL; Democratic Republic of the Congo, Congo River "Chutes Kipokosso" at Wanie Rukula, (0.1856/25.5218). – ZSM 38382, 1, 69.1 mm SL; Democratic Republic of the Congo, Congo River obtained from local fishermen at Kinsuka rapids, exact collecting location unclear (–4.3278/15.2306).

Orthochromis torrenticola (Thys van den Audenaerde, 1963): MRAC 140100, 1, holotype, 67.3 mm SL; Democratic Republic of the Congo, Lufira River rapids, just above the main falls at Kiubo, Congo, no GPS data available. – MRAC 140101, 1, paratype, 67.3 mm SL; Democratic Republic of the Congo, Lufira River rapids, just above the main falls at Kiubo, Congo, no GPS data available. – ZSM 38201, 5, 37.2–52.3 mm SL; Democratic Republic of the Congo, drainage Congo, Lufira River near Mwashia village near small rapids (–10.7008/27.3403).

Orthochromis uvinzae De Vos & Seegers, 1998: ZSM 41430, 7, 57.2–80.8 mm SL; Tanzania, Malagarasi River close to Uvinza (–5.1183/30.38). – ZSM 41562, 5, 63.7–83.9 mm SL; Tanzania, Malagarasi River, riffles/rapids upstream of Uvinza (–5.1889/30.0517). – ZSM 41564, 5, 56.6–73.3 mm SL; Tanzania, Malagarasi River, riffles/rapids upstream of Uvinza (–5.1889/30.0517).

Orthochromis **sp. "Igamba"**: ZSM 41561, 5, 49.9–73.1 mm SL; Tanzania, Malagarasi River, Igamba cataracts approximate 56 river km downriver of Uvinza (–5.1803/30.0531). – ZSM 41563, 3, 57.0–79.3 mm SL; Tanzania, Malagarasi River, Igamba cataracts approximate 56 river km downriver of Uvinza (–5.1803/30.0531).

Orthochromis **sp. "Kasinsha"**: ZSM 41429, 11 out of 13, 45.1–75.6 mm SL; Zambia, Mutoloshi stream above Kapuma falls at Mporokoso on road Mukunsa–Luwinga (–9.3889/30.0956). – ZSM 41443, 5, 40.6–63.8 mm SL; Zambia, Kasinsha stream north of Luwinga affluent to Lake Mweru (–9.4894/30.5769).

Orthochromis **sp. "Mambilima"**: ZSM 41450, 7 out 8, 27.8–58.5 mm SL; Zambia, Luapula River below Mambilima falls (–10.5689/28.6783).

Schwetzochromis neodon Poll, 1948: RG 79591-79644, 12, ♂ 75.6–93.8 mm SL; ♀ 75.6–93.8 mm SL; Democratic Republic of the Congo, River Fwa, Brousalm, no GPS data available.

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