

A New, Isolated Population of Carp Gudgeon (*Hypseleotris*) From Karijini National Park, Western Australia, With Phylogenetic Analyses

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Keywords: Freshwater fish, Phylogenetics, Cryptic species, Pilbara, ND2

<https://doi.org/10.70880/001c.157751>

Abstract

The Pilbara Freshwater Fish Biogeographic Province (Pilbara Province) of northern Western Australia is home to 15 described native freshwater fishes, with two representatives from *Hypseleotris* (carp gudgeons): the empire gudgeon *H. compressa*, and the golden carp gudgeon *H. aurea*. *Hypseleotris compressa* is widespread across northern and southeastern Australia also occurring in south-central Papua New Guinea and New Britain, whereas *H. aurea* is endemic to the Pilbara and mostly restricted to the Murchison and Gascoyne Rivers in the province's south. Here, we present phylogenetic analyses of three specimens resembling *Hypseleotris* collected from Karijini National Park, outside of the typical range of *H. compressa* and *H. aurea*. A description of their collection location and habitat is also provided. The specimens formed a strongly supported monophyletic lineage within *Hypseleotris*, being at least 8.7% divergent from their closest relative *H. aurea* across 1,047 bp of the ND2 mitochondrial gene region. Their minimum divergence from *H. aurea* was greater than that recorded between several described *Hypseleotris* species from northwest Australia and the Indo-Pacific region, providing preliminary support for recognition as a distinct species. Our results add to the growing body of genetic evidence suggesting there are more native freshwater fish species in the Pilbara Province than the 15 currently described, highlighting the need for phylogenetic studies in conservation planning for the region's ichthyofauna.

INTRODUCTION

The Pilbara Province of Western Australia, which extends from the De Grey River east of Port Hedland, to the Greenough River on the Geraldton Sandplains (Fig. 1), is one of ten freshwater fish biogeographic provinces in Australia (Unmack 2001; Unmack 2013). It is one of the most arid provinces. Annual rainfall is typically less than 400 mm, and streamflow mostly occurs in response to cyclonic activity or tropical lows in the summer wet season. However, some water persists where river channels intersect shallow aquifers, or gorges limit infiltration and evaporation (Masini 1988; Morgan *et al.* 2009; Pinder *et al.* 2010). These habitats provide critical refugia for 12 species of native, surface-dwelling freshwater fishes, with representatives from Terapontidae (grunters; three species), Atherinidae (hardyheads; one species), Melanotaeniidae (rainbowfishes; one species), Clupeidae (herrings; one species), Gobiidae (gobies; one species), Ariidae (fork-tail catfishes; one species), Plotosidae (eel-tail catfishes; one species), Anguillidae (freshwater eels; one species) and Eleotridae (gudgeons; two species) (Morgan & Gill 2004). Remarkably, the Pilbara Province also hosts three obligate subterranean fishes from Synbranchidae (swamp eels; one species) and Eleotridae (two species) (Morgan *et al.* 2014). Recent phylogenetic studies have shown that local representatives of Terapontidae, Plotosidae and Clupeidae likely represent cryptic species endemic to the region (Bostock *et al.* 2006; Morgan *et al.* 2014; Unmack 2013).

Among the Pilbara Province's described freshwater fishes are two species from *Hypseleotris* (Eleotridae); the empire gudgeon *Hypseleotris compressa* Krefft, and the golden carp gudgeon *Hypseleotris aurea* Shipway (Morgan & Gill 2004). *Hypseleotris compressa* is distributed across southeastern and northern Australia, including the coastal reaches of most of the Pilbara Province's major river systems (Fig. 1), as well as south-central Papua New Guinea (Shelley *et al.* 2023; Thacker & Unmack 2005) and New Britain Island off Papua New Guinea's northeast coast (Keith & Mennesson 2023). *Hypseleotris aurea* is endemic to the Pilbara and mostly restricted to the Murchison and Gas-

coyne rivers in the province's south (Fig. 1). An outlying Australian Museum record of *H. aurea* from 1981 also exists from a tributary of the Fortescue River (verified by Morgan & Gill 2004), which is over 200 km from the nearest *H. aurea* population (of the Gascoyne River) and separated by several major catchments (Fig. 1).

Here, we present phylogenetic analyses of specimens resembling *Hypseleotris* collected from a gorge pool in Karijini National Park (hereafter referred to as 'the Karijini population'), approximately 15 km upstream of the 1981 Australian Museum record of *H. aurea* (Fig. 1). Due to its unique and isolated occurrence, our aim was to determine whether the Karijini population belongs to the genus *Hypseleotris* and, if so, to investigate its phylogenetic relationship to *H. compressa* and *H. aurea*, and other *Hypseleotris* from the Australasian region.

MATERIAL AND METHODS

Study material

Several specimens from the Karijini population were collected as by-catch in a macroinvertebrate sample during an aquatic ecological survey in November 2024. Three were deceased in the sample, which were placed in an ice slurry and then preserved in 100% ethanol. Additional live specimens were photographed in a small viewing tank (Fig. 2), before being returned alive to the capture site. The ethanol-preserved specimens were stored in a freezer prior to analysis. One ethanol-preserved *Hypseleotris aurea* specimen previously collected from the Gascoyne River near Yinnetharra Station was included in the analysis for comparative purposes.

Molecular analysis

DNA was extracted from dorsal fin clippings of the preserved fish using the QIAGEN DNeasy Blood and Tissue extraction Kit at the labo-

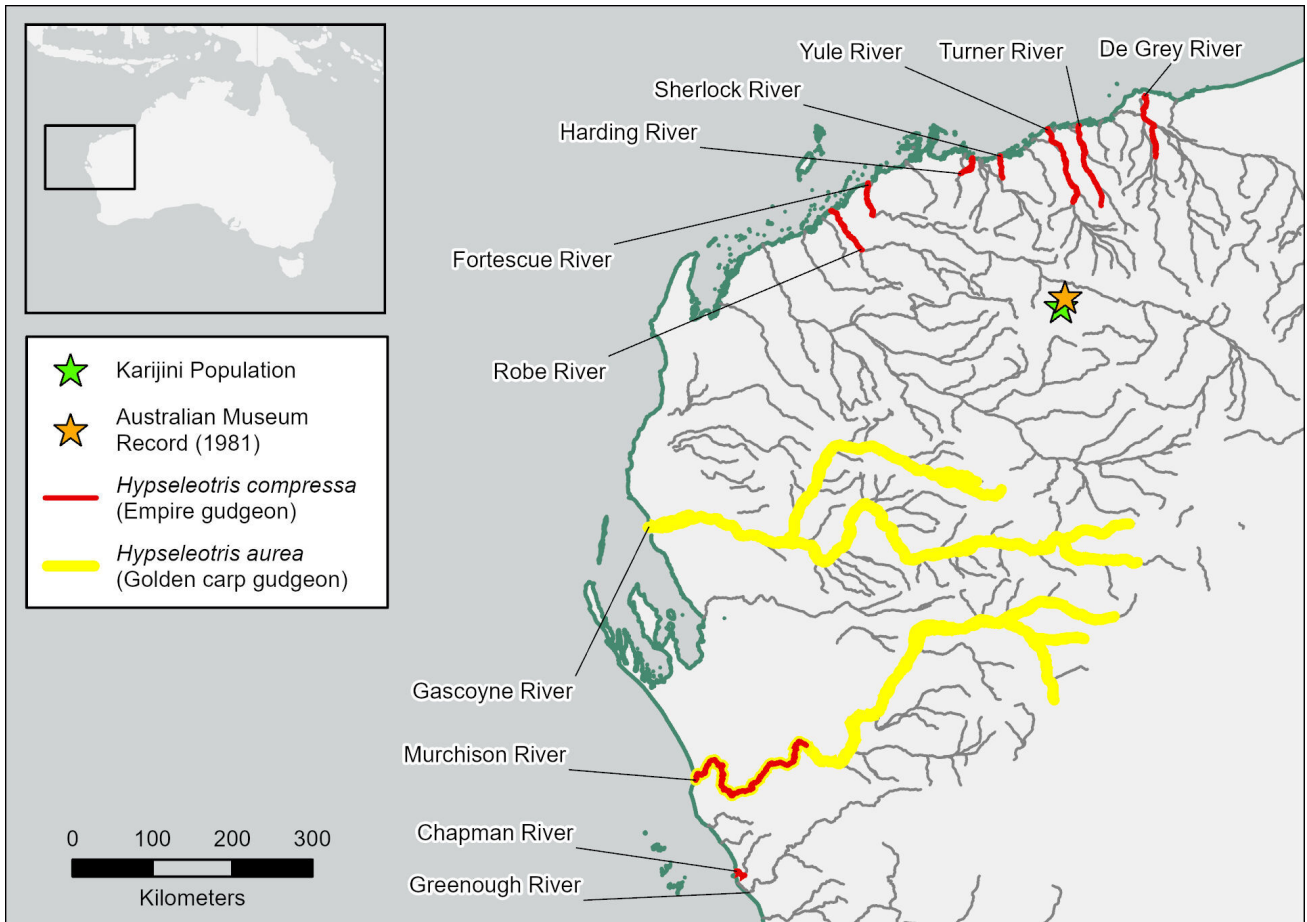


Figure 1. *Hypseleotris* distribution in the Pilbara Province (based on Morgan & Gill 2004).

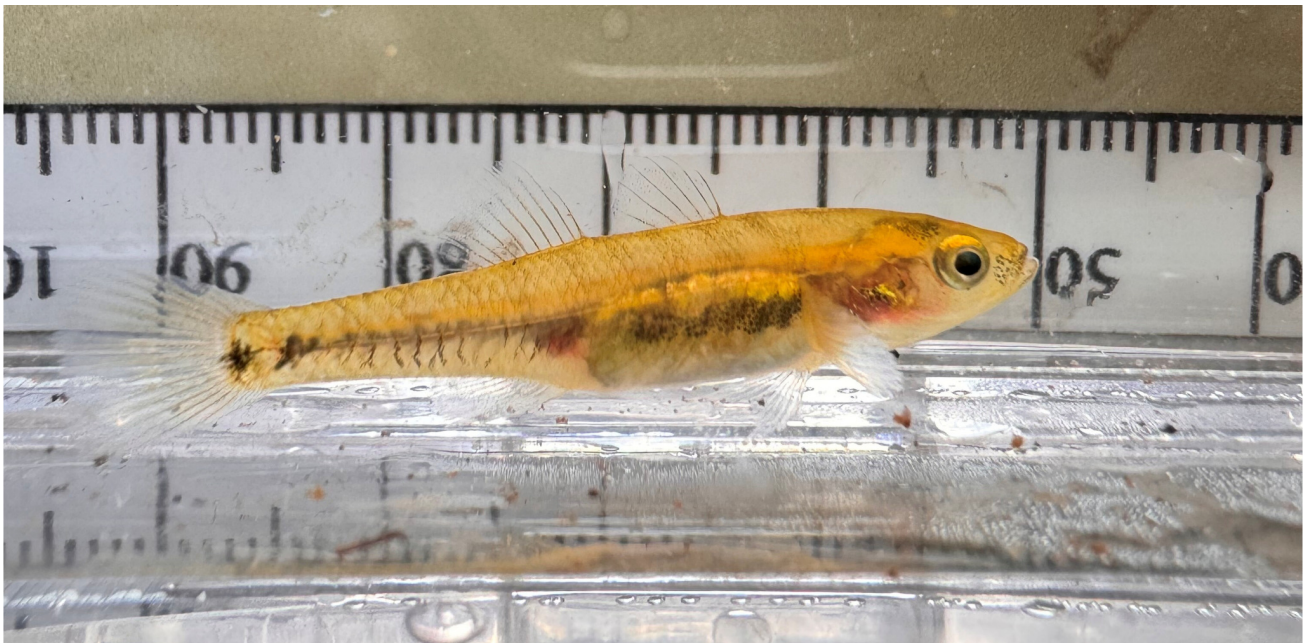


Figure 2. Freshly caught specimen from the Karijini population with natural colouration.

ratory of Biologic Environmental, Western Australia. Two primer sets (GOBY L4919 and GOBY H5513; HYPSL5464 and GOBY H6064; Thacker & Unmack 2005) were used to amplify overlapping segments of the mitochondrial ND2 (NADH dehydrogenase subunit 2) gene.

Amplified PCR products were sequenced using bidirectional Sanger sequencing at the Australian Genomic Research Facility (AGRF), Perth. Raw sequence data were edited and assembled in GENEIOUS Prime (Kearse *et al.* 2012), and the final consensus sequences were

compared against the GenBank database (<https://www.ncbi.nlm.nih.gov/genbank/>), using the “blastn” function. Reference sequences of other *Hypseleotris* species were retrieved from the GenBank nucleotide database (Table 1). Additional ND2 sequences were derived from UCE-enriched genomic reads deposited in the NCBI SRA repository under BioProject PRJNA774634, kindly provided by Christine E. Thacker (Table 1).

The selected sequences were aligned using the Multiple Alignment using Fast Fourier Transform (MAFFT) algorithm (Katoh *et al.* 2002). Phylogenetic trees were reconstructed using two approaches: Maximum Likelihood (ML) and Bayesian Inference (BI). The ML tree was generated with the RaxML (Stamatakis 2014) plugin in GENEIOUS Prime, using 1,000 bootstrap replicates and the GTR+G substitution model. BI was performed in BEAST 1.10.5 (Suchard *et al.* 2018), using Markov chain Monte Carlo (MCMC) sampling every 1,000 generations over a total of 10 million generations. The maximum clade credibility tree (posterior probability limit set to 0.95) for BI was reconstructed in TreeAnnotator. The final phylogenetic tree images obtained from ML and BI were visualised in FigTree v.1.4.3 (<http://tree.bio.ed.ac.uk/software/figtree>).

Since the ML and BI analysis generated congruent topologies, only the BI tree is presented here, with both ML bootstrap values (BS) and BI posterior probabilities (BPP) indicated at the nodes. Uncorrected genetic distances (p-distances) were calculated in GENEIOUS Prime. The sequences were deposited in GenBank (Accession Numbers PX619673, PX619674, PX619675 and PX619676).

RESULTS

Habitat description

The habitat of the Karijini population comprised a narrow (<5 m), moderately deep (>1.5 m) pool confined within a steep, amphitheatre-shaped gorge. A series of stepped, rocky ledges covered in a thick biofilm/algal layer were present on the pool’s margins, before a steep drop off in the centre. No aquatic macrophytes, woody debris or other in-stream micro-habitats were present. The target fish were abundant in the pool (over 200 specimens observed), and favoured the top third of the water column, mostly hovering above the peripheral rocky ledge. No other fish species were observed at the time of collection.

The collection site is situated at the headwaters of a short (<30 km long) tributary of the Fortescue River. Between wet season flow events, numerous disconnected pools persist where bedrock and cliff faces would limit infiltration and evaporation. The system drains in a north-easterly and then northerly direction through a series of gorges, before emptying via alluvial fan into the central Fortescue Valley floodplain; an area containing a mosaic of interconnected, highly ephemeral claypans. It is likely the system rarely connects with the Fortescue River main channel, except during very large flooding events.

Phylogenetic analysis

The mitochondrial ND2 gene segment (1,047 bp) was successfully amplified from three specimens from the Karijini population (BMR16944, BMR17252, BMR17251) and the *H. aurea* specimen from the Gascoyne River (BMR16943). Phylogenetic analyses of the ND2 dataset, including other *Hypseleotris* sequences, yielded congruent topologies in both BI and ML, with the Karijini population forming a distinct and strongly supported monophyletic lineage within the *Hypseleotris* genus (BPP = 1.0, BS = 100; Fig. 3). The closest lineage to the Karijini population in the phylogenetic tree was *H. aurea* with strong support (BPP = 1.0, BS = 100; Fig. 3). The Karijini population was more than 8.6% divergent from *H. aurea*, and between 11.6–18.9% divergent from other *Hypseleotris* species (Table 2).

DISCUSSION

The Karijini population represents a distinct lineage within *Hypseleotris*, forming a well-supported clade sister to *H. aurea* (Fig. 3). The lowest divergence between the Karijini population and *H. aurea* (8.7%) exceeded that between several recognised congeners in the analysis. For example, *H. butchinsi* was 8.5–10.0% divergent from *H. compressa*, *H. ejuncida* differed by only 2.5% from *H. regalis*, and *H. galii* by 4.1–4.4% from *H. acropinna* (Table 2). Its minimum divergence from *H. aurea* was also greater than that reported between various *Hypseleotris* species from Indo-Pacific islands, including *H. ebneri* and *H. guentheri* (8.0–8.4%), *H. ebneri* and *H. alexis* (7.7–8.5%), and *H. guentheri* and *H. alexis* (4.0–4.8%) (Keith & Mennesson 2023). These comparatively low interspecific distances among other *Hypseleotris* species highlight the clear genetic distinction of the Karijini population from *H. aurea* (and other congeners), providing preliminary support for its recognition as a separate species.

Besides the 1981 Australian Museum record of *H. aurea*, which we consider likely belongs to the Karijini population given its occurrence on the same tributary, and *H. compressa*, which has a coastal distribution, there are no verified *Hypseleotris* records from the Pilbara Province outside of the Gascoyne and Murchison rivers. This is despite a relatively recent, extensive regional ichthyological survey (Morgan & Gill 2004), and numerous aquatic ecological impact assessment studies for mining projects by various consultancy firms (e.g. Biologic Environmental, Stantec Australia, WRM, Streamtec; see Appendix Table 1). As such, there is a strong possibility that the Karijini population is restricted to the 15 km stretch of tributary between the Australian Museum record and our collection location. Many *Hypseleotris* of northwest Australia are range-restricted, and it is not uncommon for species to be endemic to one catchment or sub-catchment, or even single creeks or rivers (Morgan & Gill 2004; Shelley *et al.* 2018; Thacker & Unmack 2005; Unmack 2001). Examples from the nearby Kimberley Province include *H. wunduwala*, limited to three locations on the Carson River, a tributary of the King Edward River, and *H. maranda* which only occurs at Garimbu Creek within the Roe River catchment (Shelley *et al.* 2023). It is likely that the Karijini population and *H. aurea* once shared a common, more widespread ancestor, with populations becoming isolated in response to acidification during the late Miocene and Pleistocene, as has been postulated for other range-restricted *Hypseleotris* in northwest Australia (Thacker & Unmack 2005). Presently, the highly ephemeral Fortescue Valley floodplain at the downstream terminus of its home tributary may prevent dispersal into the broader Fortescue River catchment, while sheltering the population from predatory fishes.

Our results add to the growing body of genetic evidence that there are likely to be more freshwater fishes in the Pilbara Province than the 15 formally described. Bostock *et al.* (2006) found evidence for two cryptic species among the province’s endemic Fortescue grunters (*Leiopotherapon abencus*), while the Pilbara’s bony bream (*Nematolosa erebi*) and Hyrtl’s tandan (*Neosilurus hyrtlui*) are also genetically distinct from those of neighbouring provinces, each likely representing an undescribed endemic species (Morgan *et al.* 2014; Unmack 2013). More broadly, Hammer *et al.* (2013) proposed there may be twice as many freshwater fishes in Australia than currently recognised, due to cryptic speciation. Against the backdrop of an expansive mining industry, for which the Pilbara is renowned (Morgan *et al.* 2014), and increasing reports of invasive aquatic species, with sailfin molly (*Poecilia latipinna*) and redclaw crayfish (*Cherax quadricarinatus*) being recently introduced to the Fortescue River catchment (Pinder *et al.* 2019; Thorburn *et al.* 2018), there is a need for more frequent, robust phylogenetic studies to aid conservation planning for the Pilbara Province’s freshwater fishes. To this end, further genetic work is required to untangle the phylogeny of the Pilbara Province’s various *Hypseleotris* populations. There are few publicly available sequences for *H. aurea* of the Gascoyne River (limited to those used in this

Table 1. Collection details of *Hypseleotris* specimens included in the phylogenetic analysis, showing sampling localities, GenBank accession or BioSample numbers, and corresponding data sources or references.

Species	Sample ID	GenBank Accession/ BioSample No.	Locality/Site	Source/Reference
Karijini population	BMR16944	PX619674	Karijini National Park, Western Australia (WA), Australia	Present study
	BMR17252	PX619675		
	BMR17251	PX619676		
<i>Hypseleotris aurea</i>	AF514370	AF514370	Gascoyne River, WA, Australia	Thacker & Unmack (2005)
	AF514369	AF514369		Shelley <i>et al.</i> (2023); Thacker <i>et al.</i> (2022)
	ABTC 68432	SAMN22568934		Present study
	BMR16943	PX619673		
<i>Hypseleotris klunzingeri</i>	NC_043852	NC_043852	Balonne River at St George, Queensland (Qld), Australia	Schmidt & McDougall (2019)
	OP882651	OP882651	Richmond River, New South Wales (NSW), Australia	CSIRO Applied Genomics Initiative
	AF514380	AF514380	Back Creek, Qld, Australia	Thacker & Unmack (2005)
<i>Hypseleotris acropinna</i>	OP882650	OP882651	Dawson Creek, South Australia, Australia	CSIRO Applied Genomics Initiative
	AF514391	AF514391	Severn River, Qld, Australia	Thacker & Unmack (2005)
<i>Hypseleotris</i> sp. HAxHB	KT716513	KT716513	Pranjip Creek, Victoria, Australia	Schmidt & McDougall (2019)
<i>Hypseleotris galii</i>	AF514375	AF514375	Georges River, NSW, Australia	Thacker & Unmack (2005)
<i>Hypseleotris compressa</i>	AB560916	AB560916	Unknown	GenBank
	OP168798	OP168798	Water Lily Hole, New Britain, Papua New Guinea	Keith & Mennesson (2023)
	OP168800	OP168800		
	OP168799	OP168799		
<i>Hypseleotris gymnocephala</i>	OP882647	SAMN31703011	Meadow Creek, NSW, Australia	CSIRO Applied Genomics Initiative
<i>Hypseleotris bucephala</i>	AF514384	AF514384	Barcoo River, Qld, Australia	Thacker & Unmack (2005); Thacker <i>et al.</i> (2022)
	AF514385	AF514385		
	AF514386	AF514386		
	AF514389	AF514389		
<i>Hypseleotris alexis</i>	OP168815	OP168815	New Caledonia	Keith & Mennesson (2023)
	OP168814	OP168814	Solomon Islands	
	OP168813	OP168813		
<i>Hypseleotris guentheri</i>	OP168809	OP168809	New Caledonia	
	OP168806	OP168806		
	OP168802	OP168802		
	OP168803	OP168803		
<i>Hypseleotris ebneri</i>	OP168817	OP168817	Water Lily Hole, New Britain, Papua New Guinea	

Species	Sample ID	GenBank Accession/ BioSample No.	Locality/Site	Source/Reference
	OP168818	OP168818		
	OP168816	OP168816		
<i>Hypseleotris cyprinoides</i>	OP168819	OP168819	Gouloué, Mayotte, Comoros Islands	
	OP168820	OP168820		
	AF514366	AF514366	Japan	Thacker & Unmack (2005)
	OM971860	OM971860	Guangzhou, China	Pan <i>et al.</i> (2023)
<i>Hypseleotris wunduwala</i>	Z45598	SAMN22568965	Carson River, King Edward River, WA, Australia	Shelley <i>et al.</i> (2023); Thacker <i>et al.</i> (2022)
<i>Hypseleotris kimberleyensis</i>	2D078	SAMN22568955	Barnett River, Fitzroy River, WA, Australia	
<i>Hypseleotris garawudjirri</i>	Z45717	SAMN22568966	Charnley River, WA, Australia	
<i>Hypseleotris maranda</i>	Z28943	SAMN22568964	Garimbu Creek, Roe River, WA, Australia	
<i>Hypseleotris ejuncida</i>	2D725	SAMN22568938	Prince Regent River, WA, Australia	
<i>Hypseleotris regalis</i>	Z45679	SAMN22568963	Prince Regent River, WA, Australia	
<i>Hypseleotris hutchinsi</i>	2D218	SAMN22568953	Mitchell River, WA, Australia	
<i>Hypseleotris barrawayi</i>	MAGNT A05849	SAMN22568935	Katherine River, Daly River, Northern Territory, Australia	

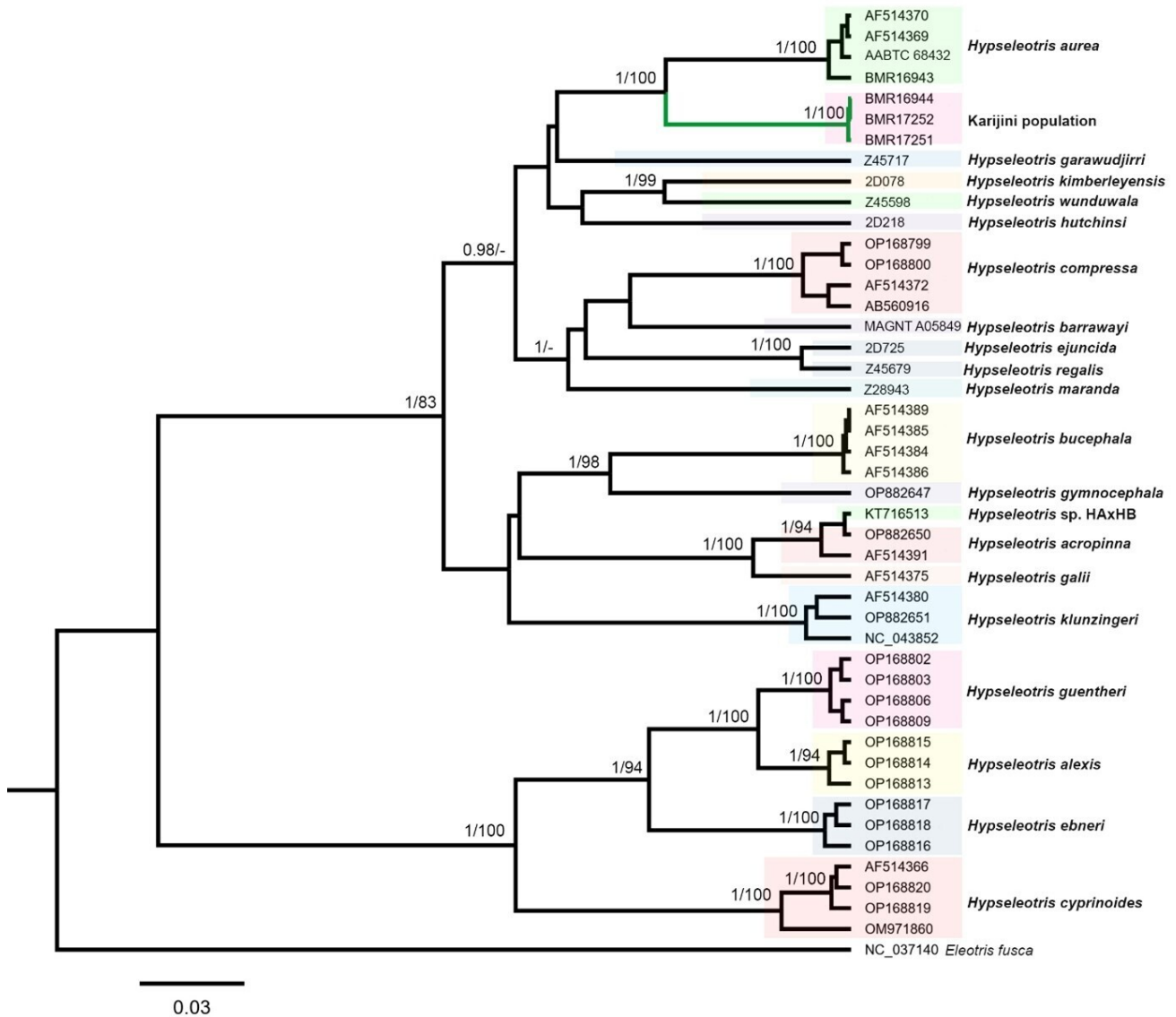


Figure 3. Phylogenetic tree estimated using the BI method in BEAST v1.10.5, depicting the relationships of mitochondrial ND2 gene among *Hypseleotris* species. Node support is indicated by Bayesian posterior probabilities/bootstrap values, shown only where values were greater than 0.95 and 75%, respectively.

study), and we could not source any genetic information for *H. aurea* of the Murchison River. Detailed morphological work would also be required to investigate differences between the populations and potentially aid in the description of the Karijini population as a new species.

CONCLUSIONS

The Karijini population, potentially restricted to a single tributary of the Fortescue River, represents a distinct genetic lineage within *Hypseleotris*. Its minimum divergence from sister species *H. aurea* is greater than that recorded between several described *Hypseleotris* species from northwest Australia and the Indo-Pacific region, providing strong support for recognition as a separate species, though further genetic and morphological work is required to untangle its phylogeny. Our results add to the increasing number of putative freshwater fishes being reported in the Pilbara province based on genetic evidence. Against the backdrop of an expansive mining industry and increasing spread of invasive species, there is a growing need for further genetic work to aid conservation planning for the Pilbara Province's ichthyofauna.

ACKNOWLEDGEMENTS

This study was funded by Biologic Environmental (Biologic). Several of our colleagues at Biologic are thanked for their contributions, particularly Shriya Bhattacharya who performed specimen subsampling and laboratory analysis, Diana Brittain who created the map, and Jess Delaney for reviewing the draft manuscript. Thanks also to Suzi Wild (BHP) and the Karijini National Park rangers for their endorsement of the study. We are grateful to Dr. Christine E. Thacker for providing sequences of *Hypseleotris* species collected from Western Australia. The specimens used in this study were collected under the following licences and permits: Fauna Taking (Biological Assessment) Licences (Regulation 27) BA27000421-4 and BA27001076, issued by the Western Australian Department of Biodiversity, Conservation and Attractions (DBCA); Regulation 4 Authority-8(1) CE006993 issued by DBCA; Instrument of Exemption to the Fish Resources Management Act – Section 7(2) exemption numbers EXEM250976722 and EXEM251252424, issued by the Western Australian Department of Primary Industries and Regional Development (DPIRD); and Li-

Table 2. Uncorrected pairwise p-distances (%) among species and lineages included in the phylogenetic analysis. Maximum and minimum distances are included, with only a single value shown when both are the same.

SL	Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	<i>Hypseleotris acropinna</i>	1.4																			
2	<i>Hypseleotris aurea</i>	12.8-13.0	0.2-1.1																		
3	<i>Hypseleotris barrawayi</i>	12.4-12.5	12.9-13.1																		
4	<i>Hypseleotris bucephala</i>	13.7-14.0	15.5-16.0	14.6-14.8	0.2-0.4																
5	<i>Hypseleotris compressa</i>	11.9-12.6	11.8-12.8	10.2-10.6	14.9-15.7	0.4-2.8															
6	<i>Hypseleotris cyprinoides</i>	17.4-18.1	18.7-19.2	19.0-19.2	20.2-20.9	18.2-19.2	0.7-3.5														
7	<i>Hypseleotris ejuncida</i>	12.3-12.5	12.1-12.5	11.7	15.5-15.6	10.8-11.6	18.6-19.0														
8	<i>Hypseleotris galii</i>	4.1-4.4	13.4-13.7	13.2	13.5-13.7	12.0-12.5	17.6-18.1	11.8													
9	<i>Hypseleotris garawudjirri</i>	12.6-13.2	12.0-12.2	13.4	14.6-14.8	11.6-12.4	18.7-19.0	12.1	12.7												
10	<i>Hypseleotris guentberi</i>	19.4-19.6	18.4-19.1	18.5-18.7	20.5-20.9	17.7-18.5	11.1-12.3	17.4-17.6	19.8-19.9	18.3	0.3-1.2										
11	<i>Hypseleotris gymnocephala</i>	12.9-13.4	14.3-14.7	14.8	12.9-13.1	13.6-14.0	19.8-20.0	14.8	12.8	14.6	20.5-20.8										
12	<i>Hypseleotris hutchinsi</i>	10.9-11.3	10.3-10.5	10.0	13.3-13.5	8.5-10.0	15.6-16.0	10.3	11.3	9.6	16.0-16.1	13.7									
13	Karijini population	13.2-13.4	8.7-9.0	13.5	15.5-15.9	11.8-12.3	17.9-18.7	12.8	13.2-13.4	12.1	18.1-18.9	14.3	10.7								
14	<i>Hypseleotris kimberleyensis</i>	13.0-13.1	13.0-13.3	12.3	15.0-15.2	12.9-14.0	17.6-17.9	14.0	13.0	13.5	18.4-18.8	14.8	10.2	13.3-13.4							
15	<i>Hypseleotris klunzingeri</i>	10.0-10.7	11.4-12.0	11.5-12.0	13.1-13.8	10.6-11.8	16.4-17.4	10.9-11.4	9.3-9.9	11.7-12.0	17.4-18.2	11.6-11.8	9.6-9.9	11.7-12.5	11.6-12.0	1.9-2					
16	<i>Hypseleotris maranda</i>	11.6-11.8	12.3-12.5	11.3	14.4-14.6	11.1-12.0	18.6-18.9	11.7	12.3	13.0	18.3	14.9	10.1	12.2-12.3	12.1	11.6-12.1					
17	<i>Hypseleotris regalis</i>	12.1	12.6-13.0	11.8	15.0-15.1	11.2-11.8	18.5-18.8	2.5	11.7	12.0	17.3-17.4	14.5	10.5	13.2	14.2	11.7-12.0	11.6				
18	<i>Hypseleotris alexis</i>	18.9-19.3	17.8-18.3	18.1	20.3-21.0	17.7-19.0	10.9-11.8	17.2-17.4	19-19.3	17.8-18.0	4.1-4.8	19.9-20.1	15.1-15.4	17.5-17.8	18.3-18.5	16.9-17.7	17.6-17.8	16.9-17.1	0.3-1		
19	<i>Hypseleotris ebneri</i>	18.2-18.6	17.8-18.4	17.4-17.9	18.9-19.2	17.2-17.7	11.0-12.0	16.6-17.0	18.7-19.0	17.2-17.5	7.9-8.3	19.2-19.6	15.4-15.7	18.3-18.7	17.6-18.1	16.5-17.1	17.5-18.0	16.4-16.8	7.6-8.3	0.7-1.2	
20	<i>Hypseleotris</i> sp. HAXHB	0.3-1.4	12.7-12.9	12.4	13.8-13.9	11.8-12.4	17.9-18.1	12.2	4.3	12.9	19.5-19.7	12.9	10.8	13.1-13.2	13.0	10.0-10.2	11.7	12.0	18.8-19.1	18.4-18.7	
21	<i>Hypseleotris wunduwala</i>	15.0-15.1	14.8-15.0	14.2	16.0-16.2	14.0-14.6	18.7-19.1	15.2	15.3	13.9	18.5-18.9	15.3	12.2	13.7-13.8	10.9	13.1-13.6	14.7	14.8	18.1-18.3	18-18.6	15.2

cence to use animals for scientific purposes U244/ 2022-2024, administered through DPIRD.

Submitted: November 28, 2025 AWST. Accepted: February 09, 2026 AWST. Published: February 28, 2026 AWST.



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APPENDIX

Appendix Table : Grey literature cited.

Author	Title	Source
Biologic Environmental	Weeli Wolli Spring: Aquatic monitoring Wet and Dry 2022	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/marillana-creek-yandi-life-mine-proposal-significant-amendment
Biologic Environmental	Weeli Wolli Spring: Aquatic monitoring Wet 21 and Dry 21	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/marillana-creek-yandi-life-mine-proposal-significant-amendment
Biologic Environmental	Ministers North: Yandicoogina Creek Aquatic Ecosystem Survey Dry 2022 and Wet 2023	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/marillana-creek-yandi-life-mine-proposal-significant-amendment
Biologic Environmental	Ministers North: Yandicoogina Creek Aquatic Ecosystem Surveys	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/marillana-creek-yandi-life-mine-proposal-significant-amendment
Biologic Environmental	McPhee Creek Project: Aquatic Ecology Survey and Assessment	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/marillana-creek-yandi-life-mine-proposal-significant-amendment
Biologic Environmental	MAC Phase 4 Aquatic Monitoring Dry 2022 and Wet 2023	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/marillana-creek-yandi-life-mine-proposal-significant-amendment
Biologic Environmental	Greater Paraburdoo Iron Ore Hub: Aquatic Ecosystem Survey Report 2019-2020	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/marillana-creek-yandi-life-mine-proposal-significant-amendment
Stantec Australia	Mallina Gold Project – Baseline Aquatic Ecology Study of the Yule and Turner Rivers	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/hemi-gold-project
Stantec Australia	Mallina Gold Project – Baseline Aquatic Ecology Study of the Yule and Turner Rivers, Flood Study Memorandum	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/hemi-gold-project
WRM	Mesa H Project: Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/mesa-h-proposal-revision-mesa-j-iron-ore-development
WRM	Mesa A / Warrambo Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/mesa-hub-revised-proposal
WRM	Mesa B and C Project Baseline Aquatic Ecosystem Survey Wet Season Sampling 2016	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/mesa-hub-revised-proposal
WRM	Warrambo Project: Baseline Aquatic Ecosystem Survey Wet Season Sampling 2018	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/mesa-hub-revised-proposal
Streamtec	Mesa ‘J’ Project Aquatic Ecosystem Pools Study	EPA Western Australia Website: https://www.epa.wa.gov.au/proposals/mesa-h-proposal-revision-mesa-j-iron-ore-development