

Primary vesicoureteral reflux in children with renal hypoplasia: prevalence and severity according to history of febrile urinary tract infection

Satoshi Hibino

shibino@med.showa-u.ac.jp

SHOWA Medical University

Naoya Fujita

Aichi Children's Health and Medical Center

Eiji Hisamatsu

Aichi Children's Health and Medical Center

Kazuki Tanaka

Aichi Children's Health and Medical Center

Katsumi Mizuno

SHOWA Medical University

Research Article

Keywords: renal hypoplasia, vesicoureteral reflux, febrile urinary tract infection, voiding cystourethrography, congenital anomalies of the kidney and urinary tract

Posted Date: October 21st, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11254711/v1>

License:  This work is licensed under a Creative Commons Attribution 4.0 International License.

[Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Purpose

To evaluate the prevalence and severity of vesicoureteral reflux (VUR) in children with strictly size-defined renal hypoplasia according to febrile urinary tract infection (fUTI) history, and to characterize associated dimercaptosuccinic acid (DMSA) findings and subsequent clinical course.

Methods

We retrospectively reviewed children younger than 15 years diagnosed with renal hypoplasia between 2002 and 2019. Renal hypoplasia was defined as renal length < -2.0 standard deviations using age- or height-based Japanese reference values. VUR was assessed by voiding cystourethrography (VCUG).

Results

Eighty-four children with 113 hypoplastic kidneys were included. VCUG provided evaluable data for 101 kidneys; VUR was present in 48 (47.5%), including grade III–V VUR in 42 (87.5%). Among children undergoing VCUG, VUR was detected in 30/33 (90.9%) with prior fUTI and 10/42 (23.8%) without prior fUTI; grade III–V VUR was present in 29/33 (87.9%) and 7/42 (16.7%), respectively (both $P < 0.001$). DMSA cortical defects were more frequent with prior fUTI (59.5% vs 16.0%) and with high-grade VUR (62.2% vs 9.1%) (both $P < 0.001$). Among 43 children without prior fUTI followed for at least 1 year (median 7.1 years), subsequent fUTI was documented in two under routine clinical management.

Conclusion

High-grade VUR was common in renal hypoplasia and was strongly associated with prior fUTI, but also occurred without prior fUTI and was not reliably excluded by the absence of hydronephrosis. These findings support an individualized, risk-informed approach to VCUG.

What is Known – What is New

What is Known

- Renal hypoplasia is associated with VUR.
- Data on VUR severity and outcomes without prior fUTI are limited.

What is New

- In strictly size-defined renal hypoplasia, grade III–V VUR occurred in 16.7% of children without prior fUTI; most high-grade VUR kidneys lacked hydronephrosis.

- DMSA cortical defects were associated with prior fUTI and high-grade VUR; subsequent fUTI was uncommon over a median 7.1 years under routine management.

Introduction

Congenital renal hypoplasia is an important cause of chronic kidney disease in children and is frequently associated with congenital anomalies of the kidney and urinary tract (CAKUT), including vesicoureteral reflux (VUR) [1]. In many children, hypoplastic kidneys are initially detected following evaluation for febrile urinary tract infection (fUTI) associated with VUR [2]. A recent study of children with incidentally detected unilateral small kidneys also reported VUR in approximately one-third of patients [3]. High-grade VUR is frequently associated with congenital renal parenchymal abnormalities and may also increase the risk of recurrent fUTI [2]. However, the relative contributions of congenital renal abnormalities, VUR, and recurrent infection to long-term kidney dysfunction remain incompletely understood.

Recent randomized controlled trials have shown that continuous antibiotic prophylaxis can reduce the occurrence of first or recurrent urinary tract infection in children with VUR, but have not demonstrated a corresponding short-term reduction in renal scarring or decline in kidney function [4, 5]. Whether these findings can be extrapolated to the long-term renal outcomes of children with pre-existing renal hypoplasia remains uncertain.

An additional clinical question is whether voiding cystourethrography (VCUG) should be routinely performed in children with hypoplastic kidneys who have no history of fUTI. VCUG allows assessment of VUR as well as structural abnormalities of the bladder and urethra [6]. At our institution, VCUG was historically included in the evaluation of renal hypoplasia to identify associated CAKUT that might influence long-term urological and renal management, even in the absence of prior fUTI. However, the prevalence and severity of VUR in children with well-defined renal hypoplasia, particularly those without prior fUTI, remain incompletely characterized, and reports describing subsequent clinical management and fUTI are limited.

The aims of this study were to evaluate the prevalence and severity of VUR in children with renal hypoplasia according to fUTI history, to examine the associations of VUR severity and fUTI history with renal cortical defects on DMSA scintigraphy, and to describe clinical management and subsequent fUTI in children without prior fUTI.

Materials and methods

Study design and participants

This retrospective cohort study was conducted at Aichi Children's Health and Medical Center, a tertiary pediatric nephrology and urology referral center. We reviewed the medical records of children diagnosed with renal hypoplasia between May 2002 and April 2019. Children younger than 15 years at diagnosis were eligible for inclusion.

Eligibility criteria

Renal hypoplasia was defined as a renal length <-2.0 standard deviations (SDs) according to the reference values for Japanese children reported by Fujita et al. [7]. Height-based reference values were used when height data were available, and age-based reference values were used when height data were unavailable. Obvious multicystic dysplastic changes were excluded. Children initially diagnosed at other institutions were eligible if subsequent evaluation at our center confirmed these criteria. Children with ectopic ureter, neurogenic bladder, posterior urethral valve, or severe hydronephrosis requiring pyeloplasty that precluded accurate assessment of renal size were excluded. Initially, 91 children were identified; after application of the exclusion criteria, 84 children with 113 hypoplastic kidneys were included in the final analysis.

Data collection and imaging assessment

Clinical data were obtained from medical records, including sex, age at diagnosis of renal hypoplasia, history of fUTI, imaging findings, and follow-up duration. During the earlier part of the study period, VCUG and DMSA scintigraphy were generally included in the evaluation of children diagnosed with renal hypoplasia irrespective of fUTI history. As clinical practice evolved, these investigations were deferred or omitted in selected clinically stable children without prior fUTI when there was no immediate indication for further urological evaluation; consequently, they were not performed uniformly in all participants.

VCUG findings were reviewed to determine the presence and grade of VUR according to the International Reflux Study grading system (grades I–V) [8]. Grades III–V were defined as high-grade VUR. In children with bilateral VUR, the higher grade was used for patient-level analyses. Renal ultrasonography was performed in all included children, and hydronephrosis was graded according to the Society for Fetal Urology system [9]. DMSA scintigraphy findings were reviewed to identify renal cortical defects, including generalized cortical defects with loss of renal contour and focal cortical defects, in accordance with current practice guidance [10]. Kidneys with radionuclide uptake $<1\%$ were excluded from cortical-defect evaluation because reliable assessment was not possible.

Outcome measures

The primary outcomes were the prevalence and severity of VUR in the overall cohort and according to fUTI history. Secondary outcomes were clinical management and subsequent fUTI among children without prior fUTI, the distribution of hydronephrosis according to VUR grade, and the associations of fUTI history and high-grade VUR with renal cortical defects on DMSA scintigraphy. For the analysis of subsequent fUTI among children without prior fUTI, only those with at least 1 year of follow-up within the study period were included. Follow-up began at the first visit to our institution for children managed without intervention and at initiation of treatment for those who received continuous antibiotic prophylaxis (CAP) or antireflux surgery. Follow-up ended at the last documented visit within the study period, including transfer to another institution, or at initiation of kidney replacement therapy, whichever occurred first.

Statistical analysis

Analyses of fUTI were performed at the patient level, whereas DMSA scintigraphy and ultrasonography were analyzed at the kidney level. VUR was analyzed at both patient and kidney levels. Categorical variables were compared using Fisher’s exact test, and continuous variables are presented as medians with interquartile ranges (IQRs) and were compared using the Mann–Whitney U test. Associations of fUTI history with VUR presence and high-grade VUR were expressed as odds ratios (ORs) with 95% confidence intervals (CIs). Statistical analyses were performed using EZR version 1.70 (Saitama Medical Center, Jichi Medical University, Saitama, Japan) [11]. Two-sided P values <0.05 were considered statistically significant.

Results

Patient characteristics (Table 1)

Table 1 Patient characteristics	
Children, n	84
Unilateral renal hypoplasia, children, n (%)	55 (65.5%)
Bilateral renal hypoplasia, children, n (%)	29 (34.5%)
Kidneys, n	113
Male/female, n	63/21
Median age at diagnosis, years (IQR)	1.0 (0.3–7.2)
History of febrile UTI, children, n (%)	34 (40.5%)
No history of febrile UTI, children, n (%)	50 (59.5%)
VCUG performed, children, n (%)	75/84 (89.3%)
Hypoplastic kidneys with evaluable VUR data, n (%)	101/113 (89.4%)
DMSA scintigraphy performed, kidneys, n (%)	92/113 (81.4%)
Abbreviations: DMSA, dimercaptosuccinic acid; IQR, interquartile range; UTI, urinary tract infection; VCUG, voiding cystourethrography.	

A total of 84 children (63 boys and 21 girls) with 113 hypoplastic kidneys were included. Renal hypoplasia was unilateral in 55 children and bilateral in 29. The median age at diagnosis was 1.0 years (IQR 0.3–7.2 years).

Prevalence and severity of vesicoureteral reflux

VCUG was performed in 75 of 84 children, yielding evaluable VUR data for 101 of 113 included kidneys. The median age at VCUG was 1.7 years (IQR 0.6–7.5 years). VUR was identified in 48 kidneys (47.5%): grade V in 15 (31.3%), grade IV in 13 (27.1%), grade III in 14 (29.2%), grade II in 3 (6.3%), and grade I in 3 (6.3%). Overall, 42 of 48 refluxing kidneys (87.5%) had high-grade VUR.

Association between VUR and febrile urinary tract infection (Table 2)

Table 2
Prevalence and severity of VUR according to history of febrile UTI

Characteristic	fUTI	Non-fUTI	P value
Age at diagnosis of renal hypoplasia, years, median (IQR)	0.9 (0.4–5.4)	2.3 (0.0–8.1)	0.67
VCUG performed, children, n/total	33/34	42/50	—
VUR positive, children, n/VCUG (%)	30/33 (90.9%)	10/42 (23.8%)	< 0.001
Grade V, children, n/VUR-positive	11/30	2/10	—
Grade IV, children, n/VUR-positive	9/30	2/10	—
Grade III, children, n/VUR-positive	9/30	3/10	—
Grade II, children, n/VUR-positive	1/30	2/10	—
Grade I, children, n/VUR-positive	0/30	1/10	—
High-grade VUR (III–V), children, n/VCUG (%)	29/33 (87.9%)	7/42 (16.7%)	< 0.001
Note: Patient-level VUR grade was the highest grade recorded in either kidney. High-grade VUR was defined as grade III–V and was compared among all children who underwent VCUG.			
Abbreviations: fUTI, febrile urinary tract infection; IQR, interquartile range; VCUG, voiding cystourethrography; VUR, vesicoureteral reflux.			

A history of fUTI was documented in 34 of 84 children; 50 had no history of fUTI. The median age at diagnosis of renal hypoplasia was 0.9 years (IQR 0.4–5.4) in children with prior fUTI and 2.3 years (IQR 0.0–8.1) in those without prior fUTI (P = 0.67).

Among the 34 children with prior fUTI, 33 underwent VCUG and VUR was detected in 30 (90.9%): grade V in 11, grade IV in 9, grade III in 9, grade II in 1, and grade I in none. Among the 50 children without prior fUTI, 42 underwent VCUG and VUR was detected in 10 (23.8%): grade V in 2, grade IV in 2, grade III in 3, grade II in 2, and grade I in 1.

VUR was significantly more frequent in children with prior fUTI than in those without prior fUTI (90.9% vs 23.8%; OR 30.0, 95% CI 7.2–186.1; P < 0.001). Among children who underwent VCUG, high-grade VUR was also more frequent in the fUTI group (87.9% vs 16.7%; OR 33.6, 95% CI 8.5–176.0; P < 0.001).

Follow-up in children without prior febrile urinary tract infection

Among the 50 children without prior fUTI, 43 had at least 1 year of follow-up. During a median follow-up of 7.1 years (IQR 4.5–11.7), one of two children with grade V VUR underwent ureteral reimplantation and the other received CAP; neither developed subsequent fUTI. Of two children with grade IV VUR, one received CAP followed by ureteral reimplantation, whereas the other developed fUTI during observation and subsequently started CAP. Three children with grade III VUR, one with grade II VUR, and one with grade I VUR received no intervention and had no documented subsequent fUTI. Among 29 children without VUR, 28 received no intervention and had no documented subsequent fUTI. The remaining child received CAP because of severe contralateral hydronephrosis requiring surgery and developed fUTI; the affected kidney could not be determined. Five additional children did not undergo VCUG; none received intervention or developed documented subsequent fUTI.

Hydronephrosis according to VUR grade

Among 101 kidneys with evaluable VUR data, ultrasonographic hydronephrosis data were available for all 101. The median age at ultrasonography was 3.6 years (IQR 1.4–9.0). Of 15 kidneys with grade V VUR, 12 had no hydronephrosis, one had SFU grade 1, one grade 2, and one grade 3. Of 13 kidneys with grade IV VUR, 12 had no hydronephrosis and one had SFU grade 1. Of 14 kidneys with grade III VUR, 12 had no hydronephrosis, one had SFU grade 1, and one grade 2. Of 3 kidneys with grade II VUR, two had no hydronephrosis and one had SFU grade 1. None of the 3 kidneys with grade I VUR had hydronephrosis. Among 53 kidneys without VUR, 47 had no hydronephrosis, five had SFU grade 1, and one had SFU grade 4.

DMSA scintigraphy findings

DMSA scintigraphy was performed in 92 of 113 kidneys (81.4%). Renal cortical defects were identified in 30 of 87 kidneys evaluable for cortical defects after excluding five kidneys with radionuclide uptake < 1% (34.5%). Among 41 kidneys from children with prior fUTI, DMSA scintigraphy was performed in 37, all of which were evaluable; cortical defects were identified in 22 (59.5%). Among 72 kidneys from children without prior fUTI, DMSA scintigraphy was performed in 55; cortical-defect evaluation was possible in 50, with defects identified in 8 (16.0%). Cortical defects were significantly more frequent in kidneys from children with prior fUTI (59.5% vs 16.0%, $P < 0.001$).

Among 81 kidneys with evaluable DMSA findings and available VCUG data, renal cortical defects were present in 23 of 37 kidneys (62.2%) with high-grade VUR and 4 of 44 (9.1%) without high-grade VUR ($P < 0.001$).

Discussion

In this retrospective cohort, VUR was present in nearly half of evaluated hypoplastic kidneys and was predominantly high grade. At the patient level, both VUR and high-grade VUR were substantially more frequent in children with prior fUTI. Prior fUTI and high-grade VUR were each associated with renal cortical defects on DMSA scintigraphy. Among children without prior fUTI, documented subsequent fUTI was uncommon during long-term follow-up, although some children with high-grade VUR received CAP or surgical intervention.

Previous studies have reported a frequent association between small kidneys and VUR. Mohammadi et al. identified VUR in 28 of 86 children (32.6%) with incidentally detected unilateral small kidneys [3]. In our cohort, VUR was identified in 48 of 101 evaluated hypoplastic kidneys (47.5%), and 87.5% of refluxing kidneys had grade III–V VUR. VUR was also detected in 10 of 42 children (23.8%) without prior fUTI, including high-grade VUR in 7 (16.7%). Our study adds data from both unilateral and bilateral renal hypoplasia defined using standardized age- or height-based renal-length criteria, with assessment according to fUTI history, DMSA findings, and subsequent clinical management.

A history of fUTI was strongly associated with both the presence and severity of VUR: among children who underwent VCUG, VUR was present in 90.9% of those with prior fUTI compared with 23.8% without prior fUTI, and high-grade VUR was present in 87.9% and 16.7%, respectively. Prior fUTI therefore represents an important clinical marker for significant VUR in children with renal hypoplasia and supports a low threshold for considering VCUG in this setting.

DMSA scintigraphy demonstrated renal cortical defects in 59.5% of evaluable kidneys from children with prior fUTI compared with 16.0% from those without prior fUTI. Cortical defects were also more frequent in kidneys with high-grade VUR than in those without high-grade VUR (62.2% vs 9.1%). These findings identify prior fUTI and high-grade VUR as clinically relevant markers of renal cortical abnormalities. Because DMSA cortical abnormalities may reflect congenital renal parenchymal changes, acquired post-infectious scarring, or both [2, 10], these associations should not be interpreted as evidence of causation.

Recent randomized trials provide important context. In RIVUR, antimicrobial prophylaxis reduced recurrent febrile or symptomatic UTI but did not significantly reduce renal scarring during two years of follow-up [4]. In PREDICT, CAP reduced the occurrence of a first UTI in infants with grade III–V VUR, whereas new kidney scarring and estimated glomerular filtration rate at 24 months were similar between groups [5]. These trials addressed treatment after VUR diagnosis, whereas our study addresses children with pre-existing renal hypoplasia in whom VUR was sought during urinary tract evaluation. The clinical questions are therefore complementary, and longer-term studies focused on renal hypoplasia are needed to clarify the renal significance of detecting and treating VUR in this population.

Among 43 children without prior fUTI followed for at least 1 year, subsequent fUTI was documented in only two during a median follow-up of 7.1 years. Children with grade IV–V VUR often received CAP and/or surgical intervention, whereas the three children with grade III VUR were managed without intervention and had no documented subsequent fUTI. Thus, the observed low frequency of subsequent

fUTI describes the clinical course under routine management rather than the untreated natural history of VUR.

Most kidneys with high-grade VUR did not show hydronephrosis. Hydronephrosis was nevertheless observed in a small subset of kidneys with high-grade VUR. Accordingly, the absence of hydronephrosis should not be used to exclude clinically significant VUR in children with renal hypoplasia, consistent with guidance that ultrasonography alone cannot reliably exclude VUR [12]. Conversely, the presence of hydronephrosis or other urinary tract abnormalities may strengthen the indication for further urological evaluation, including VCUG.

VCUG may also contribute information beyond VUR by demonstrating structural abnormalities of the bladder and urethra that can affect long-term urological management [6]. This may become relevant in selected children who later develop advanced CKD and require lower urinary tract evaluation before kidney transplantation [13]. In our cohort, prior fUTI strongly identified children with clinically significant VUR, whereas high-grade VUR still occurred in a substantial minority without prior fUTI and was not reliably excluded by absence of hydronephrosis. These findings favor an individualized, risk-informed approach to VCUG.

This study has several limitations. Its retrospective, single-center referral design may limit generalizability and increase the observed prevalence of urinary tract anomalies. Although renal hypoplasia was defined using standardized age- or height-based ultrasonographic renal-length criteria, histological confirmation was unavailable, and mild dysplastic change or an acquired small kidney could not always be excluded. Indications for VCUG and DMSA scintigraphy evolved during the study period, and VUR management was not standardized. VCUG and ultrasonography were not always performed contemporaneously. DMSA analyses were performed at the kidney level without accounting for within-patient correlation between bilateral kidneys, and congenital cortical abnormalities could not always be distinguished from acquired post-infectious scarring.

In conclusion, high-grade VUR was common in children with renal hypoplasia and was particularly frequent among those with prior fUTI. Prior fUTI and high-grade VUR were both associated with renal cortical defects on DMSA scintigraphy. Among children without prior fUTI, documented subsequent fUTI was uncommon during long-term clinical follow-up under routine management. Prior fUTI provides a strong clinical reason to consider VCUG, whereas in children without prior fUTI, clinically significant VUR cannot be reliably excluded by absence of hydronephrosis alone. These findings support an individualized, risk-informed approach to VCUG in children with renal hypoplasia.

Abbreviations

CAKUT, congenital anomalies of the kidney and urinary tract; CAP, continuous antibiotic prophylaxis; CI, confidence interval; CKD, chronic kidney disease; DMSA, dimercaptosuccinic acid; eGFR, estimated glomerular filtration rate; fUTI, febrile urinary tract infection; IQR, interquartile range; OR, odds ratio; SD,

standard deviation; SFU, Society for Fetal Urology; VCUG, voiding cystourethrography; VUR, vesicoureteral reflux.

Statements and Declarations

Funding

The authors declare that no funds, grants, or other support were received during the preparation of this manuscript.

Competing interests

The authors have no relevant financial or non-financial interests to disclose.

Author contributions

Satoshi Hibino contributed to study conception and design, data acquisition, statistical analysis, interpretation of the findings, and drafting of the manuscript. Naoya Fujita and Kazuki Tanaka contributed to data acquisition and interpretation of nephrological findings and critically reviewed the manuscript. Eiji Hisamatsu contributed to acquisition and interpretation of urological and imaging data and critically reviewed the manuscript. Katsumi Mizuno supervised the study and critically revised the manuscript. All authors read and approved the final manuscript and agree to be accountable for all aspects of the work.

Ethics approval

This study was conducted in accordance with the Declaration of Helsinki and was approved by the Institutional Review Board of Aichi Children's Health and Medical Center (approval No. 2026037).

Consent to participate

The requirement for informed consent was waived because of the retrospective nature of the study, and information regarding the study was disclosed on the institutional website with an opt-out option.

Consent to publish

Not applicable.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

1. Sanna-Cherchi S, Caridi G, Weng PL, Scolari F, Perfumo F, Gharavi AG, Ghiggeri GM (2007) Genetic approaches to human renal agenesis/hypoplasia and dysplasia. *Pediatr Nephrol* 22:1675–1684. <https://doi.org/10.1007/s00467-007-0479-1>
2. Polito C, La Manna A, Rambaldi PF, Nappi B, Mansi L, Di Toro R (2000) High incidence of a generally small kidney and primary vesicoureteral reflux. *J Urol* 164:479–482. [https://doi.org/10.1016/S0022-5347\(05\)67404-6](https://doi.org/10.1016/S0022-5347(05)67404-6)
3. Mohammadi M, Ebrahimi K, Khafri S, Nikpour M, Sorkhi H (2025) Vesicoureteral reflux in children with accidental diagnosis of unilateral small size kidney. *Urol Res Pract* 50:230–233. <https://doi.org/10.5152/tud.2025.24060>
4. RIVUR Trial Investigators (2014) Antimicrobial prophylaxis for children with vesicoureteral reflux. *N Engl J Med* 370:2367–2376. <https://doi.org/10.1056/NEJMoa1401811>
5. Morello W, Baskin E, Jankauskiene A et al (2023) Antibiotic prophylaxis in infants with grade III, IV, or V vesicoureteral reflux. *N Engl J Med* 389:987–997. <https://doi.org/10.1056/NEJMoa2300161>
6. Frimberger D, Mercado-Deane MG, Section on Urology, Section on Radiology (2016) Establishing a standard protocol for the voiding cystourethrography. *Pediatrics* 138:e20162590. <https://doi.org/10.1542/peds.2016-2590>
7. Fujita N, Uemura O, Harada R et al (2022) Ultrasonographic reference values and a simple yet practical formula for estimating average kidney length in Japanese children. *Clin Exp Nephrol* 26:808–818. <https://doi.org/10.1007/s10157-022-02205-0>
8. Lebowitz RL, Olbing H, Parkkulainen KV, Smellie JM, Tamminen-Möbius T (1985) International system of radiographic grading of vesicoureteric reflux. *Pediatr Radiol* 15:105–109. <https://doi.org/10.1007/BF02388714>
9. Fernbach SK, Maizels M, Conway JJ (1993) Ultrasound grading of hydronephrosis: introduction to the system used by the Society for Fetal Urology. *Pediatr Radiol* 23:478–480. <https://doi.org/10.1007/BF02012459>
10. Vali R, Armstrong IS, Bar-Sever Z et al (2022) SNMMI procedure standard/EANM practice guideline on pediatric [99mTc]Tc-DMSA renal cortical scintigraphy: an update. *Clin Transl Imaging* 10:173–184. <https://doi.org/10.1007/s40336-022-00484-x>
11. Kanda Y (2013) Investigation of the freely available easy-to-use software “EZR” (Easy R) for medical statistics. *Bone Marrow Transplant* 48:452–458. <https://doi.org/10.1038/bmt.2012.244>
12. Miyakita H, Hayashi Y, Mitsui T et al (2020) Guidelines for the medical management of pediatric vesicoureteral reflux. *Int J Urol* 27:480–490. <https://doi.org/10.1111/iju.14223>
13. Evans-Barns H, Mushtaq I, Michell I, Kausman J, Webb N, Taghavi K (2022) Paediatric kidney transplantation: towards a framework for pretransplant urological evaluation. *Pediatr Transplant* 26:e14299. <https://doi.org/10.1111/petr.14299>