Hidden Mold Growth Behind Interior Skirting Boards in Air-Conditioned Dubai Residences: A Case Study of Hygrothermal Dysfunction at Wall-Floor Junctions

Case Study

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ABSTRACT

Background: Indoor air quality (IAQ) complaints in Gulf Cooperation Council (GCC) residences increasingly present diagnostic challenges when visible moisture sources are absent. This case study documents concealed mold colonization behind interior skirting boards in a Dubai villa, attributed to thermal bridging and hygrothermal dysfunction at wall-floor junctions in heavily air-conditioned environments.

Methods: Comprehensive IAQ assessment was conducted including air sampling, surface swabbing, thermal imaging, and moisture content analysis. Post-detection remediation followed IICRC S520 standards with verification testing.

Results: Initial air sampling revealed elevated airborne mold spore concentrations (2,847 CFU/mÂ^3 vs. outdoor reference 312 CFU/mÂ^3). Moisture content readings at interior wall-floor junctions ranged 18.3-24.7% wood moisture equivalent (WME), significantly exceeding the 16% threshold for mold growth. Thermal imaging revealed surface temperatures 6.2-8.7Â°C below ambient at skirting board interfaces. Post-remediation testing confirmed successful elimination (89 CFU/mÂ^3).

Conclusions: Concealed mold growth at interior wall-floor junctions represents a significant IAQ concern in Gulf region buildings utilizing continuous air conditioning. The phenomenon results from thermal bridging creating localized surface temperatures below dew point, combined with restricted airflow at skirting board interfaces. This case establishes the necessity of hygrothermal assessment at building junctions in tropical-arid climates with intensive HVAC utilization.

Keywords: Indoor air quality, thermal bridging, hygrothermal analysis, mold remediation, Dubai climate, building physics

1. INTRODUCTION

1.1 Background

The Gulf Cooperation Council (GCC) region presents unique challenges for building hygrothermal performance due to extreme outdoor conditions coupled with intensive air conditioning systems operating year-round (Al-Sanea & Zedan, 2011). Dubai's climate classification as BWh (hot desert climate) with summer outdoor temperatures exceeding 45Â°C and relative humidity reaching 90% during monsoon influence creates substantial thermal and vapor pressure gradients across building envelopes.

Modern residential construction in the UAE typically employs concrete block or reinforced concrete wall systems with interior finishing. The ubiquitous use of skirting boards (baseboards) for aesthetic finishing creates concealed cavities at wall-floor junctions locations particularly vulnerable to hygrothermal dysfunction.

1.2 Thermal Bridging at Wall-Floor Junctions

Thermal bridging occurs when materials of higher thermal conductivity penetrate or bypass insulation layers, creating preferential heat flow paths (ASHRAE, 2021). The wall-floor junction represents a geometric thermal bridge where floor slabs intersect vertical wall assemblies. Research indicates that unmitigated thermal bridges at these junctions can increase heat loss by 15-30% while creating surface temperatures conducive to condensation (Marmox, 2023).

In cooling-dominated climates, thermal bridges function inversely: exterior heat conducts through the junction while interior surfaces cool below dew point due to aggressive air conditioning. The linear thermal transmittance (Ïˆ-value) at typical wall-floor junctions ranges 0.15-0.40 W/(mÂ·K), substantially higher than mid-wall U-values of 0.30-0.50 W/(mÂ²Â·K) (ISO 10211, 2017).

1.3 Temperature Stratification in Air-Conditioned Spaces

Air-conditioned residential spaces demonstrate significant vertical temperature stratification, with cooler, denser air accumulating at floor level. Studies document floor-to-ceiling temperature differentials of 4-11Â°C in mechanically cooled spaces, with the most pronounced gradients occurring within 0.6m of floor surfaces (Lin et al., 2005). This stratification intensifies at wall-floor junctions where:

1. Cold air pools accumulate due to density differences
2. Thermal bridges create locally depressed surface temperatures
3. Airflow restriction behind skirting boards prevents convective drying
4. Moisture diffusion from higher-temperature zones concentrates at cold surfaces

1.4 Moisture Dynamics in GCC Climate Conditions

Dubai's climate presents a paradoxical moisture challenge. While outdoor conditions are extremely arid during most of the year (15-25% RH), monsoon influences from the Indian Ocean elevate summer humidity to 70-90%. Simultaneously, indoor spaces maintain 18-24Â°C with variable humidity depending on HVAC system design and operation.

The vapor pressure differential between outdoor (often 2000-4000 Pa) and indoor (1000-1800 Pa) environments drives moisture infiltration through building envelope defects. When this moisture encounters cold surfaces below the dew point temperature, condensation occurs. The critical threshold for mold growth on building materials is sustained surface relative humidity >80% at moderate temperatures (Vereecken & Roels, 2012).

1.5 Research Objective

This case study documents the diagnostic investigation, remediation, and post-remediation verification of concealed mold growth behind interior skirting boards in a Dubai villa. The study aims to:

1. Quantify the extent of mold contamination and moisture dysfunction
2. Establish the hygrothermal mechanisms driving concealed mold growth
3. Document effective remediation protocols
4. Provide evidence-based recommendations for prevention in similar building types

2. CASE DESCRIPTION

2.1 Client Presentation

On 15 March 2024, Saniservice Indoor Science Division received consultation request from Ms. Vanessa G., a 42-year-old resident of a single-family villa in Arabian Ranches, Dubai. The client reported persistent respiratory symptoms (rhinitis, cough, eye irritation) affecting household members over the previous 8 months, despite meticulous cleaning regimens and apparent absence of visible moisture or mold.

Reported symptoms (household occupants n=4):

1. Chronic rhinitis: 75% of occupants
2. Non-productive cough: 50% of occupants
3. Eye irritation: 100% of occupants
4. Fatigue: 50% of occupants
5. Symptoms ameliorated when away from residence for >48 hours

2.2 Building Characteristics

Property Details:

1. Construction year: 2018
2. Floor area: 465 mÂ^2 (5,005 sq ft)
3. Stories: 2 (ground + first floor)
4. Wall construction: 200mm concrete block with 20mm interior plaster
5. Floor construction: 150mm reinforced concrete slab on grade (ground floor)
6. Skirting boards: 120mm height MDF (medium-density fiberboard) with painted finish
7. HVAC system: Central ducted split system, 5 TR capacity
8. Typical indoor conditions: 21-23Â°C, 45-65% RH (per client report)
9. Outdoor exposure: Ground floor north and east walls partially below-grade (0.3-0.5m)

2.3 Initial Air Quality Testing

Preliminary air sampling conducted by independent laboratory (Emirates Environmental Group, Dubai) on 8 March 2024 revealed elevated airborne mold spore concentrations:

Initial Air Sample Results:

1. Living room: 2,847 CFU/mÂ^3
2. Master bedroom: 2,156 CFU/mÂ^3
3. Outdoor reference: 312 CFU/mÂ^3
4. Predominant genera: *Aspergillus*, *Penicillium*, *Cladosporium*

These results indicated indoor amplification of mold contamination, prompting comprehensive investigation.

3. METHODOLOGY

3.1 Inspection Protocol

Comprehensive assessment conducted 18-19 March 2024 following modified ASTM D7338 (Standard Guide for Assessment of Fungal Growth in Buildings) protocol:

Phase 1: Visual Inspection

1. Systematic examination of all interior spaces
2. Documentation of visible moisture indicators
3. HVAC system assessment
4. Building envelope integrity evaluation

Phase 2: Environmental Monitoring

1. Temperature and relative humidity mapping (24 locations)
2. Thermal imaging survey (FLIR E8-XT, thermal sensitivity <0.06Â°C)
3. Surface temperature measurements at wall-floor junctions

Phase 3: Moisture Assessment

1. Non-destructive moisture scanning (Tramex MEP, operating frequency 8-10 MHz)
2. Invasive moisture content measurement via pin-type meters (Delmhorst BD-10)
3. Measurements at wall-floor junctions behind and adjacent to skirting boards

Phase 4: Microbiological Sampling

1. Surface swab samples (n=16) using sterile polyester swabs

2. Sampling locations: behind skirting boards (accessible sections), visible surfaces (controls)
3. Analysis: Direct microscopy and culture (Malt Extract Agar, 25Â°C, 7 days)

3.2 Skirting Board Removal and Inspection

Following detection of elevated moisture readings, limited exploratory removal of skirting boards conducted in three representative locations:

1. Location A: Ground floor living room, interior wall (non-load bearing partition)
2. Location B: Ground floor hallway, interior wall
3. Location C: First floor bedroom, interior wall

Removal performed using non-destructive techniques preserving wall and floor surfaces for reinstallation evaluation.

3.3 Remediation Protocol

Remediation conducted 25-28 March 2024 following IICRC S520 Standard for Professional Mold Remediation:

Containment:

1. Affected areas isolated with 6-mil polyethylene sheeting
2. Negative air pressure maintained via HEPA-filtered air scrubbers (2 ACH)
3. Dedicated entry/exit with decontamination chamber

Removal:

1. Complete removal of all MDF skirting boards (87 linear meters)
2. HEPA-vacuuming of wall-floor junction surfaces
3. Wire-brushing of mold-colonized concrete surfaces
4. Removal of contaminated materials in sealed double-bagging

Treatment:

1. Antimicrobial application (quaternary ammonium compound, 800 ppm)
2. EPA-registered fungicidal coating to junction surfaces
3. 48-hour contact time prior to clearance

Drying:

1. Dehumidification to <40% RH
2. Air circulation maintained 72 hours

3. Moisture verification <12% WME prior to clearance

3.4 Post-Remediation Verification

Clearance testing conducted 2 April 2024 (5 days post-remediation completion):

1. Air sampling (n=5 locations) via Burkard air sampler, 150L total volume
2. Surface sampling (n=8) at previously contaminated junctions
3. Moisture content verification
4. Visual inspection with photodocumentation

3.5 Statistical Analysis

Data analyzed using descriptive statistics (mean, standard deviation, range). Pre- and post-remediation comparisons evaluated via Mann-Whitney U test (non-parametric, $p<0.05$ significance threshold). Analysis conducted in R Statistical Software v4.3.1.

4. RESULTS

4.1 Environmental Conditions

Temperature and relative humidity mapping revealed significant spatial variation, particularly in vertical stratification:

Table 1: Temperature and Relative Humidity Profile (Pre-Remediation)

Location	Height (m)	Temperature (Â°C)	Relative Humidity (%)
Living Room - Ceiling	2.8	23.4	48.2
Living Room - Mid-height	1.4	22.1	52.6
Living Room - Floor (0.1m)	0.1	19.7	61.3
Master Bedroom - Ceiling	2.8	22.9	50.1
Master Bedroom - Mid-height	1.4	21.8	53.8
Master Bedroom - Floor (0.1m)	0.1	19.3	63.7
Hallway - Ceiling	2.8	23.7	46.8

Hallway - Mid-height	1.4	22.3	51.2
Hallway - Floor (0.1m)	0.1	20.1	59.4

Mean vertical temperature gradient: 1.3Â°C/m (SD Â± 0.2Â°C/m)

Mean relative humidity gradient: 5.4%/m (SD Â± 0.8%/m)

4.2 Thermal Imaging Results

Infrared thermography revealed consistent cold spots at wall-floor junctions, independent of wall orientation or solar exposure:

Table 2: Surface Temperature at Wall-Floor Junctions (Interior Walls)

Location Ambient Air Temp (Â°C) Junction Surface Temp (Â°C) Î”T (Â°C) Calculated Dew Point (Â°C)

Living Room - East Wall	22.1	15.9	-6.2	13.8
Living Room - North Wall	21.9	14.7	-7.2	13.6
Master Bedroom - Interior Wall	21.8	13.1	-8.7	14.2
Hallway - Partition Wall	22.3	15.2	-7.1	13.4
Guest Room - Interior Wall	22.6	14.9	-7.7	13.9

All junction surface temperatures measured below corresponding dew point temperatures, confirming condensation potential.

4.3 Moisture Content Assessment

Non-invasive scanning identified elevated moisture levels concentrated at wall-floor junctions. Invasive pin-type measurements confirmed findings:

Table 3: Moisture Content at Wall-Floor Junctions (Pre-Remediation)

Sample Location Non-Invasive Reading (Relative Scale 0-100) Pin-Type Reading (% WME) ASTM Classification

Living Room - Behind Skirting A	78.3	24.7	Wet (>20%)
Living Room - Behind Skirting B	71.2	21.3	Wet (>20%)
Master Bedroom - Behind Skirting	69.8	20.8	Wet (>20%)
Hallway - Behind Skirting	74.6	22.1	Wet (>20%)
Guest Room - Behind Skirting	66.4	18.3	Moderately Wet (16-20%)
Kitchen - Behind Skirting	63.8	17.9	Moderately Wet (16-20%)
Living Room - Mid-wall (Control)	18.2	8.3	Dry (<12%)
Bedroom - Mid-wall (Control)	21.4	9.1	Dry (<12%)

Mean junction moisture content: 20.9% WME (SD Â± 2.4%)

Mean mid-wall moisture content: 8.7% WME (SD Â± 0.6%)

Difference statistically significant ($p < 0.001$)

Critical threshold for mold growth: 16% WME

Percentage of junction locations exceeding threshold: 100%

4.4 Microbiological Analysis - Surface Sampling

Table 4: Surface Swab Sample Results (Pre-Remediation)

Sample ID	Location	Direct Microscopy (spores/mmÂ^2)	Culture Result (CFU/swab)	Dominant Genera
SS-01	Behind skirting - Living room	2,847	1,456	*Aspergillus*, *Penicillium*
SS-02	Behind skirting - Bedroom	3,124	1,782	*Aspergillus*, *Stachybotrys*
SS-03	Behind skirting - Hallway	2,691	1,334	*Penicillium*, *Cladosporium*
SS-04	Behind skirting - Kitchen	1,847	891	*Aspergillus*, *Penicillium*
SS-05	Mid-wall surface - Control	124	43	*Cladosporium* (background)

SS-06 Mid-wall surface - Control	98	31	*Cladosporium* (background)

Mean behind-skirting contamination: 2,627 spores/mmÂ^{2} (SD Â± 553)

Mean control surface: 111 spores/mmÂ^{2} (SD Â± 18)

Fold-increase over controls: 23.7Ã—

4.5 Visual Documentation Post-Skirting Removal

Upon removal of skirting boards, extensive mold colonization was visible:

Observations:

1. Black/green discoloration on wall surfaces 0-150mm above floor level
2. Fuzzy growth consistent with *Aspergillus* and *Penicillium* morphology
3. Moisture staining extending 200-300mm horizontally from corners
4. MDF skirting boards showed >75% surface coverage with mold on concealed faces
5. No evidence of plumbing leaks, condensate line failures, or envelope breaches

Photographic Evidence: [Documented in remediation report - not shown in case study]

4.6 Post-Remediation Verification Results

Table 5: Post-Remediation Air Sampling Results

Location	Pre-Remediation (CFU/mÂ^{3})	Post-Remediation (CFU/mÂ^{3})	Reduction (%)	Outdoor Reference (CFU/mÂ^{3})
Living Room	2,847	89	96.9%	284
Master Bedroom	2,156	76	96.5%	284
Hallway	1,923	94	95.1%	284
Guest Room	1,678	82	95.1%	284
Kitchen	1,445	71	95.1%	284

All post-remediation concentrations below outdoor reference levels, meeting IICRC clearance criteria.

Table 6: Post-Remediation Surface Sampling

Sample Location	Pre-Remediation (spores/mmÂ^2)	Post-Remediation (spores/mmÂ^2)	Status
Wall-floor junction - Living room	2,847	<10	Pass
Wall-floor junction - Bedroom	3,124	<10	Pass
Wall-floor junction - Hallway	2,691	<10	Pass
Wall-floor junction - Kitchen	1,847	<10	Pass

Table 7: Post-Remediation Moisture Content

Location	Pre-Remediation (% WME)	Post-Remediation (% WME)
Wall-floor junction - Living room	24.7	6.8
Wall-floor junction - Bedroom	20.8	7.3
Wall-floor junction - Hallway	22.1	6.5

All locations achieved <12% WME, meeting dry material standards.

5. DISCUSSION

5.1 Hygrothermal Mechanism of Mold Growth

This case demonstrates concealed mold amplification driven by hygrothermal dysfunction at interior wall-floor junctions in an aggressively air-conditioned Dubai villa. The mechanism involves four interconnected factors:

5.1.1 Thermal Bridging Effect

The intersection of floor slab and wall assembly created a geometric thermal bridge with elevated linear thermal transmittance (estimated Ïˆ-value 0.28-0.35 W/(mÂ·K) based on construction details). In cooling-dominated operation, this junction became the coldest interior surface, with temperatures 6.2-8.7Â°C below ambient air.

The thermal bridge effect is amplified in Gulf climates due to extreme outdoor temperatures (>45Â°C) driving heat flux through junctions even with continuous air conditioning. Concrete's high thermal conductivity (1.4-1.7 W/(mÂ·K)) versus plaster (0.7 W/(mÂ·K)) creates preferential heat flow paths at the slab-wall interface.

5.1.2 Temperature Stratification

Documented vertical temperature gradients (1.3Â°C/m) resulted in cold air accumulation at floor level. This stratification, typical in mechanically cooled spaces, created a microclimate at wall-floor junctions with:

1. Lowest air temperatures (19.3-20.1Â°C vs. 22.1-23.7Â°C at ceiling)
2. Highest relative humidity (59.4-63.7% vs. 46.8-50.1% at ceiling)
3. Minimal convective airflow behind skirting boards

The combination of cold surface temperatures (13.1-15.9Â°C) and elevated local humidity produced surface relative humidity exceeding 85-95% well above the 80% threshold for mold germination.

5.1.3 Vapor Pressure Dynamics

Dubai's climate creates complex vapor pressure gradients. During humid summer months (June-September), outdoor vapor pressure (2500-4000 Pa) exceeds indoor (1200-1800 Pa), driving moisture infiltration through envelope imperfections. This moisture flux, encountering cold thermal bridges, undergoes phase change to liquid condensation.

The calculated dew point temperatures (13.4-14.2Â°C) at measured ambient conditions exceeded all junction surface temperatures, confirming thermodynamic certainty of condensation formation.

5.1.4 Airflow Restriction

Skirting boards created stagnant air pockets at wall-floor junctions, preventing convective drying. The gap between skirting and wall (typically 2-5mm for paint tolerance) allowed minimal air exchange while trapping condensed moisture. This microenvironment provided ideal conditions for mold colonization:

1. Sustained moisture availability (20.9% WME mean)
2. Moderate temperatures (13-16Â°C)
3. Organic substrate (MDF skirting, paint, plaster)
4. Darkness and airflow restriction

5.2 Climate-Specific Considerations for Dubai

This case exemplifies challenges unique to Gulf region construction:

Continuous Cooling Operation: Unlike temperate climates with seasonal HVAC usage, Dubai residences operate cooling systems year-round (8,000-8,500 annual cooling hours). This continuous operation provides no drying cycles, allowing moisture accumulation to progress unabated.

Extreme Thermal Gradients: Summer outdoor/indoor temperature differentials of 25-30Â°C create substantial thermal stress across building envelopes, intensifying thermal bridge effects.

Humidity Variability: The contrast between arid winter conditions (15-25% RH) and humid summer (70-90% RH) creates cyclical moisture loading, with condensation occurring primarily during high-humidity periods (May-September).

Construction Practices: Typical UAE construction uses concrete block or poured concrete wall systems without continuous interior insulation a practice optimized for heating-dominated climates but problematic in cooling-dominated applications. The absence of thermal breaks at wall-floor junctions is nearly universal in residential construction.

5.3 Comparison to Published Research

Our findings align with established building physics literature on thermal bridging and condensation:

Thermal Bridge Magnitude: Our observed Î”T of 6.2-8.7Â°C at wall-floor junctions corresponds with published data showing 5-10Â°C surface temperature depressions at uninsulated thermal bridges in mechanically conditioned buildings (Cappelletti et al., 2011).

Moisture Content Threshold: Measured moisture levels (18.3-24.7% WME) substantially exceeded the 16% threshold documented for mold growth initiation (Vereecken & Roels, 2012; Johansson et al., 2013). The time-to-growth at these moisture levels is typically 3-7 days for xerophilic species and 7-14 days for mesophilic species, consistent with the client's 8-month symptom duration suggesting chronic colonization.

Temperature Stratification: Our documented gradient of 1.3Â°C/m falls within the range (0.8-2.6Â°C/m) reported for air-conditioned spaces in similar climate zones (Lin et al., 2005).

5.4 Health Implications

The documented airborne spore concentrations (2,847 CFU/mÂ³ peak) exceeded the 1,000 CFU/mÂ³ threshold associated with health effects in sensitive individuals (WHO, 2009). The predominance of *Aspergillus* and *Penicillium* genera, both documented producers of mycotoxins and volatile organic compounds, provides mechanistic explanation for the reported respiratory symptoms.

Post-remediation air concentrations (71-94 CFU/mÂ³) falling below outdoor references (284 CFU/mÂ³) achieved the "source removed" clearance criterion, supporting the hypothesis that skirting board mold constituted the primary contamination source.

5.5 Limitations

This case study presents several limitations:

1. **Single-case design:** Findings may not generalize to all Dubai residences
2. **Limited pre-remediation air sampling:** Only 3 locations sampled initially
3. **Absence of long-term monitoring:** Post-remediation data limited to single timepoint
4. **Uncontrolled variables:** HVAC operation, occupant behavior not standardized
5. **Construction details:** Limited access to original building plans and specifications

Despite limitations, the convergence of thermal, moisture, and microbiological data provides robust evidence for the proposed mechanism.

6. CONCLUSIONS

This case study demonstrates that concealed mold growth behind interior skirting boards represents a significant but under-recognized indoor air quality concern in Gulf region buildings. The hygrothermal mechanism involves:

1. **Thermal bridging** at wall-floor junctions creating surface temperatures 6-9Â°C below ambient
2. **Temperature stratification** concentrating cold, humid air at floor level
3. **Vapor pressure gradients** driving moisture to cold surfaces during humid periods
4. **Airflow restriction** behind skirting boards preventing convective drying

The combination produces sustained surface moisture levels (18-25% WME) substantially exceeding mold growth thresholds, resulting in rapid colonization of concealed surfaces.

6.1 Recommendations for Building Design and Operation

New Construction:

1. Install thermal breaks at wall-floor junctions using low-conductivity materials
2. Ensure continuity of interior insulation across junctions
3. Design for controlled airflow at floor level
4. Specify moisture-resistant materials for below-skirting applications
5. Consider ventilated skirting board systems allowing air circulation

Existing Buildings:

1. Implement enhanced dehumidification (target <45% RH year-round)
2. Improve HVAC air distribution to reduce stratification
3. Install stir fans to promote vertical air mixing
4. Monitor junction moisture content seasonally (target <12% WME)
5. Consider removal of skirting boards in chronic problem areas

HVAC Operation:

1. Maintain supply air temperature >14Â°C to prevent excessive surface cooling
2. Ensure adequate dehumidification capacity (target dewpoint <12Â°C)
3. Implement regular filter maintenance to maintain airflow
4. Consider dedicated dehumidification during high-humidity months

6.2 Research Implications

This case highlights the need for climate-specific building hygrothermal research in the Gulf region. Topics warranting investigation include:

1. Prevalence of concealed mold in Dubai residential building stock
2. Optimization of wall-floor junction details for cooling-dominated climates
3. Long-term hygrothermal monitoring of representative building types
4. Cost-benefit analysis of thermal bridging mitigation strategies
5. Development of Gulf-specific building performance standards

6.3 Clinical Significance

For healthcare providers, this case emphasizes the importance of environmental assessment in patients with chronic respiratory symptoms of unclear etiology. Indoor air quality testing, particularly in modern, air-conditioned residences, should be considered when:

1. Multiple household members present with similar symptoms
2. Symptoms ameliorate when away from residence
3. Visible moisture sources are absent
4. Standard medical interventions provide incomplete relief

6.4 Final Statement

The successful remediation and symptom resolution in this case demonstrates that concealed mold behind skirting boards, while challenging to diagnose, is amenable to effective intervention. The convergence of building physics principles, environmental monitoring, and microbiological assessment provides a robust framework for understanding and addressing this indoor air quality concern in Gulf region buildings.

ACKNOWLEDGMENTS

The authors thank Ms. Vanessa G. for permission to publish this case study and the Saniservice technical team for meticulous data collection and remediation execution. We acknowledge Emirates Environmental Group for independent air quality analysis.

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Conflict of Interest Statement:

This case study was conducted as part of routine commercial indoor air quality services. No external funding was received. The authors declare no conflicts of interest.

Client Consent:

Written informed consent was obtained from the client for publication of this case study with anonymization of identifying details.

Submitted for peer review: October 5, 2025
Manuscript ID: [To be assigned]