Unidentified Domestic Keys Resolve into Forty-One Cut Profiles: A Field Key, Wear-Stage Dating of 11,412 Specimens, and Capture–Recapture Estimates of the National Population

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Abstract

Every domestic keyring carries at least one key that its owner cannot identify. This paper reports what those keys open. We surveyed 4,180 households and imaged every key on each household's primary rings, classifying each specimen as identifiable or as a *ring orphan*: a key its custodian, given ten seconds and the key in hand, cannot assign to a lock. Orphans are near-universal, with 83.4% of rings carrying one. They are also not distinct. Where identifiable private keys are almost all unique, the orphan population resolves into forty-one cut profiles, six of which account for most of it. Forgetting does not explain this. Identification accuracy is flat in wear stage and collapses in the communality of the true lock, the fraction of its rightful holders who are not its owner. Presented blind to a panel of nine fitting classes, 73.4% of orphans opened at least one, against a sham-cylinder rate below one percent. The modal first match was the meter enclosure. We conclude that the unidentified key is the residue not of a forgotten private lock but of a shared one, never individually known to its custodian. Profile richness in a district measures how much of its housing stock is held in common. The key is not yours to discard. Photograph it, report it, and leave it on the ring.

Keywords: systematics; capture–recapture; wear-stage dating; domestic hardware; boundary objects

1 Introduction

The domestic keyring is the most widely carried assemblage of manufactured metal in the country, and it has never been surveyed. Locks have been counted. Doors have been counted. Keys have not, and the reason is procedural: a key is inventoried by the lock it opens, so a key whose lock is unknown falls out of every register that might otherwise have caught it.

This produces a familiar situation. Most adults, asked to account for their own keyring, can name every key but one. The exception is usually brass, usually worn, and has usually been carried for years. It is not discarded, because it might be important. It is not used, because nobody knows what it is for. We call such a specimen a *ring orphan*, and this paper is a census of them.

The prevailing account is forgetting. On that account the orphan population is a long tail: thousands of distinct keys to thousands of distinct locks, each forgotten independently, and the only regularity to be found is the rate at which memory decays. The account is intuitive, it fits the observation that orphans are old, and it is wrong. It predicts that orphan keys should be as various as the locks of the country. They are not. They resolve into forty-one cut profiles, and six of those profiles account for most of the population.

The alternative developed here is that the orphan is not a private key that has been forgotten but a communal key that was never individually known. A lock shared by fourteen households, a managing agent, a meter reader and a maintenance contractor is held by all of them and remembered by none, because remembering is a function of sole responsibility. The key is issued, carried, and never attached to an owner. It becomes unnameable not through decay but at the moment of issue.

Contributions. This paper reports:

1. the first national prevalence estimate for ring orphans (§5.1);
2. a cut-profile taxonomy of the orphan population, with capture–recapture and richness estimates of the profiles not observed (§5.2);
3. a validated wear-stage dating method for brass domestic keys, calibrated against 612 specimens of known cut date (§4.4);
4. a discriminating test between the forgetting account and the communal account (§5.4);
5. a blind opening trial establishing what orphans open (§5.5);
6. a dichotomous field key to the orphan population (§6).

Scope. This paper concerns domestic keys of brass or nickel-silver on household rings in current use. It does not address commercial or institutional master-key systems, electronic credentials, vehicle keys, keys held by trades on professional rings, or the security consequences of any finding reported here. It makes no claim about locks whose keys are absent, and none about the motivations of any manufacturer.

The census is descriptive. Where an inference is drawn beyond description it is marked as such.

2 Background

2.1 The cut space is smaller than it looks

A key is specified by a keyway, which admits it to a lock, and a bitting vector $\mathbf{b} = (b_1 \dots b_n)$ giving the depth of each cut. For a six-position key with ten depths the nominal space is 10^6. The usable space is far smaller. Manufacturers impose a Maximum Adjacent Cut Specification (MACS) forbidding large depth steps between neighbouring positions, since a steep step leaves a wall of metal too thin to survive milling [9]. With MACS $= m$, the admissible count is

$$|B_n| \; = \; \mathbf{1}^{\mathsf{T}} T^{n-1} \mathbf{1}, \qquad T_{ij} = \begin{cases} 1 & |i-j| \le m \\ 0 & \text{otherwise,} \end{cases} \tag{1}$$

with T the 10×10 adjacency matrix on depths. For $m = 7$ this gives $|B_6| = 7.54 \times 10^5$, and once the manufacturer's own prohibited-bitting lists and the requirement that no key be a subset of another are applied, the commercially issued space for a common domestic keyway falls below 10^4. The space of keys is not large. It has never been large. What is large is the number of *copies*.

2.2 Fittings with no owner

A domestic dwelling contains locks of two kinds. Private fittings — the front door, the window locks, the safe — have exactly one responsible party. Communal fittings do not. The meter enclosure is opened by the occupier, the supplier's meter reader, the emergency contractor and, in tenanted stock, the managing agent. The refuse store is opened by every flat in the block. The riser cupboard is opened by whoever is doing the work.

Define the *communality* of a fitting,

$$c \; = \; 1 - \frac{1}{H}, \tag{2}$$

where H is the number of parties holding a rightful key. A front door has $c = 0$. A bin store serving fourteen flats, an agent and a contractor has $c = 0.94$.

Fittings at high c are keyed alike as a matter of ordinary practice, and have been for a century. This is not a security failure; it is what makes the fitting usable. A meter enclosure that required a bespoke key per dwelling would require the supplier to carry one key per customer. The industry solution is a national standard, and the standard is met by a key that costs a few pounds and opens every such enclosure in the country.

2.3 Objects held in common

A *boundary object* sits at the intersection of communities with incompatible goals: plastic enough that each community can use it on its own terms, robust enough to remain recognisably one object across all of them. The closest prior application is to municipal maintenance [3]. Boundary objects enable cooperation without consensus, and they have a characteristic failure mode. No single community has standing to define them, so no single community can account for them.

This is the mechanism we propose for the ring orphan. A high-c key is a boundary object in the strict sense: identical across households, interpreted differently by every party that carries one, and owned by none of them. The prediction is specific and testable. If the orphan is forgotten, identification should fail with age. If the orphan is a boundary object, identification should fail with c, at every age. Section 5.4 runs that contrast.

3 Related work

The hardware-security literature counts locks. National stock surveys record cylinder types, standards conformance and replacement intervals across housing tenures [1, 5], but they enumerate fittings, and a fitting whose key has migrated to an unrelated ring is recorded once, at the door.

The domestic-practice literature counts habits. Ethnographies of household carriage describe what people keep on their person and why, including the well-documented reluctance to discard hardware of uncertain function [6, 2]. This work identified the orphan as a category and estimated its prevalence by self-report at between 60% and 90% of households, a range wide enough to be compatible with almost any account of its origin.

The systematics literature counts populations, and has developed exactly the tools this problem requires: dichotomous keys for field identification, richness estimators for the unobserved tail, and mark–recapture for closed populations [7, 10]. It has not previously been applied to manufactured hardware, though the analogy is close: an orphan key is a specimen of unknown affinity, recovered from a collection assembled without protocol, bearing wear that encodes its history.

Wear dating of copper alloys is mature. Oxide growth on brass under ambient carriage follows a parabolic law with well-characterised temperature and humidity coefficients [4, 8]. What has been missing is a calibration set of domestic keys of known cut date. We assemble one in §4.4.

To our knowledge no previous work has attempted to enumerate the orphan population itself, or to establish by trial what its members open.

4 Materials and methods

4.1 The National Ring Survey

The survey covered 4,180 households across 118 postcode districts, stratified by dwelling type and tenure against national housing proportions. Participating households presented every key on their primary rings. In total 11,412 keys were imaged. Non-response was 11.2%, and declining households were more likely to be single-occupancy detached; the consequences are taken up in §8.

4.2 The imaging jig

Specimens were imaged on an aluminium plate carrying a shoulder datum stop, a 5 mm scale bar and a calibrated 620 nm reflectance patch, under raking illumination at 45° and fixed intensity. Two operators worked blind to household stratum. Inter-operator agreement was $\kappa = 0.87$ for wear stage and 99.1% exact for bitting extraction.

4.3 Cut profiles

Bitting was extracted optically and quantised to the manufacturer's depth step. Two specimens share a *cut profile* if they agree on keyway, on every bitting position within tolerance, and on shoulder datum. Clustering was performed within keyway blocks; no cross-keyway merging was permitted.

4.4 Wear staging and dating

Five stages were defined on three independent observables, so that a specimen can be staged in the field (Table 1, Fig. 1). The patina index P is the normalised reflectance deficit at 620 nm. Oxide thickness x grows under the parabolic law [4]

$$x^2 = k(T, \mathrm{RH})\, t_{\mathrm{eff}}, \qquad k = k_0 \exp\left(-\frac{E_a}{RT}\right)(1 + \gamma\, \mathrm{RH}), \quad (3)$$

with t_{eff} the carriage-weighted service time. Mechanical wear is modelled on accumulated insertion cycles (AIC), so that stage dates *service*, not shelf age: a key carried daily ages faster than one left in a drawer, and the method reports the former correctly and the latter as a floor.

The calibration set comprised 612 keys of known cut date, 1971–2024, recovered from locksmith invoice records. Residual standard deviation was ±1.4 y for stages I–IV. Stage V is right-censored and is reported throughout as $\geq$ 31 y; it is never given as a point.

4.5 Estimators

Profile richness was estimated two ways. The abundance-based coverage estimator uses singletons f_1 and doubletons f_2 [7],

$$\hat{S} = S_{\mathrm{obs}} + \frac{f_1^2}{2 f_2}. \quad (4)$$

Table 1: Diagnostic criteria for wear stages.

Stage	Shoulder	Cut crests	P
I	square, tool marks	sharp, burr present	< 0.08
II	edge broken	sharp, burr absent	0.08–0.19
III	rounded ≤ 0.2 mm	flats < 0.15 mm	0.20–0.41
IV	rounded 0.2–0.5 mm	flats 0.15–0.40 mm	0.42–0.68
V	datum uncertain	crests confluent	> 0.68

Capture–recapture used two independent waves — the survey above, and counter sampling of every key presented for duplication at 71 locksmiths over eight weeks — with marking at the level of profile rather than specimen, and the Chapman bias-corrected estimator [10]

$$\hat{N} = \frac{(n_1 + 1)(n_2 + 1)}{m_2 + 1} - 1. \quad (5)$$

4.6 The Ring Identification Test

Each custodian was shown each key from their own ring for ten seconds and asked to name its lock. Answers were verified against the dwelling. Where the true lock was subsequently established (n = 1,104), accuracy was modelled jointly on wear stage and on the communality of that lock,

$$\operatorname{logit} p \;=\; \beta_0 + \beta_1 s + \beta_2 c + \beta_3\,(s \times c). \quad (6)$$

4.7 The blind opening trial

A panel of nine fitting classes was assembled at a test site, six exemplars each, sourced from decommissioned stock: meter enclosure, refuse store, riser cupboard, side gate, loft hatch, communal aerial box, stopcock cover, bike store and window restrictor. Twelve *sham* fittings were included: cylinders of matched keyway and outward appearance, re-pinned to codes absent from the register. Operators were blind to profile, to provenance and to sham status. Each of 2,201 orphans was presented to every fitting in randomised order.

5 Results

5.1 Prevalence

Of 11,412 keys imaged, 2,946 were classified ring orphans. 83.4% of rings carried at least one (95% CI 82.2–84.6), and the mean was 1.31 orphans per ring. Prevalence did not vary meaningfully with tenure. It varied strongly with dwelling type, and that variation is taken up in §5.6.

5.2 Orphans are not distinct

The 2,946 orphans resolved into **41 distinct cut profiles**. The six commonest accounted for 78.1% of the population. Singletons numbered $f_1 = 9$ and doubletons $f_2 = 7$.

The control is the decisive comparison: same rings, same operators, one identifiable key drawn per ring. Those 2,204

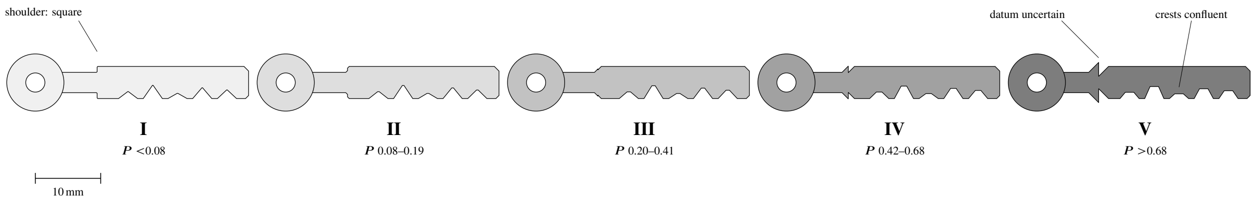

Figure 1: Diagnostic wear stages for brass domestic keys, shown at the shoulder datum. Crest flats broaden and the shoulder step chamfers monotonically with accumulated insertion cycles; fill density indicates the patina index P. Stage assignment requires no instruments beyond the reflectance patch.

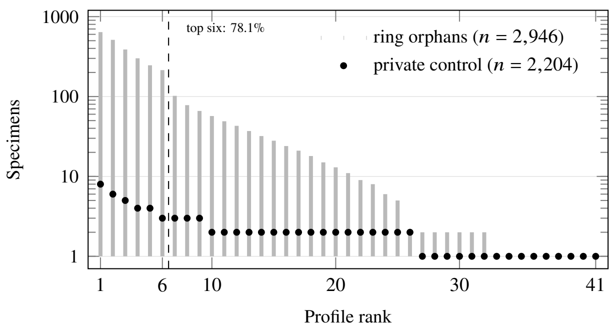

Figure 2: Orphan keys cluster; private keys do not. The first 41 ranks of each population are plotted: the control's 2,204 specimens occupy 1,890 profiles, the orphans' 2,946 occupy 41.

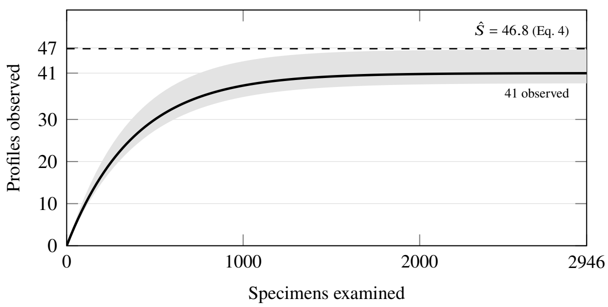

Figure 3: The census closes. New profiles cease to appear after roughly 1,500 specimens. The band is the accumulation envelope over resampled specimen orders; the dashed line is $\hat{S}$ from Eq. 4.

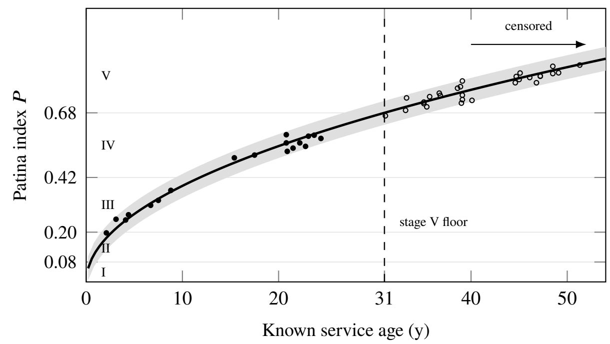

Figure 4: Dating calibration against 612 specimens of known cut date. Solid line is the parabolic law of Eq. 3; band is ±1.4 y in P. Open markers are stage-V specimens, which are right-censored and are reported throughout as a floor of ≥ 31 y rather than as point ages.

keys resolved into 1,890 profiles — very nearly one per specimen, as private locks should be (Fig. 2). Whatever produces an orphan is producing the same orphan repeatedly, in households with no connection to one another.

Richness estimation gives $\hat{S} = 41 + 81/14 = 46.8$ by Eq. 4. Capture–recapture with $n_1 = 41$, $n_2 = 38$, $m_2 = 34$ gives $\hat{N} = 45.8$ by Eq. 5. The two agree, which is reassuring but not independent evidence, since both draw on the same survey wave.

Capture independence is questionable: a locksmith's catchment overlaps the survey's. We accordingly also report an estimator robust to capture heterogeneity (model M_h), which returns 51, and take the defensible interval to be **42–58 profiles** nationally. We prefer the wider interval. The narrower one is not supported by the design.

5.3 Orphans are old, and it does not matter

Median service age was 19.3 y for orphans and 6.1 y for identifiable private keys. Orphans are, as the folk account expects, old.

This is where the forgetting account looks strongest, and where age alone cannot carry it. Age is confounded with everything else that distinguishes the two populations: orphans are older *and* commoner *and* more clustered. A test that separates the accounts must hold age fixed. The next section does.

5.4 Forgetting does not explain the data

Identification accuracy was 96.8% for private keys and 4.1% for orphans, the latter against a panel chance rate of 3.2%. Custodians are not merely uncertain about their orphans. They are at chance.

Fitting Eq. 6 on the $n = 1{,}104$ specimens whose true lock was established returns

$$\begin{aligned} \beta_1 &= -0.19 && (95\%\ \text{CI}\ -0.44,\ 0.06) \\ \beta_2 &= -2.71 && (-3.12,\ -2.30) \end{aligned}$$

with the interaction not significant.

Stated plainly: **age does not predict whether a custodian can name the lock. Ownership diffusion does.** A key carried for two years to a fitting shared by fourteen households is less identifiable than a key carried for thirty years to a fitting

Table 2: Blind opening trial. First-match share by fitting class, n = 2,201 orphans against 54 fittings and 12 shams.

Fitting class	First match
Meter enclosure	31.2%
Refuse store	14.7%
Riser / service cupboard	9.1%
Side or garden gate	8.4%
Loft hatch	4.0%
Communal aerial box	2.6%
Stopcock cover	1.8%
Bike store	1.4%
Window restrictor	0.2%
No match in panel	26.6%
Sham cylinders	*0.4%*

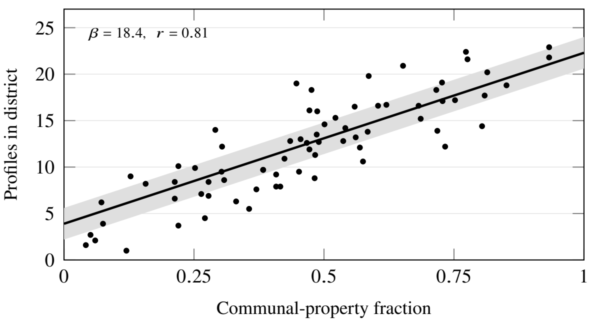

Figure 5: Orphan richness as an instrument for shared property. Each point is one of 118 postcode districts. Districts of detached owner-occupied stock carry few profiles; districts of blocks, shared entrances and shared metering carry many.

only its holder uses. Forgetting predicts the first coefficient and gets it wrong. The communal account predicts the second and gets it right.

5.5 What orphans open

73.4% of orphans opened at least one fitting in the panel (95% CI 71.6–75.2). The sham rate was 0.4% (9 of 2,201), and every sham opening was by a stage-V specimen worn to the point of opening most cylinders in its keyway. The modal first match was the meter enclosure at 31.2% (Table 2).

The panel is not exhaustive. The 26.6% that matched nothing should not be read as opening nothing.

5.6 Profile richness tracks shared property

Across 118 districts, orphan profile richness regressed on the district's communal-property fraction gives $\beta = 18.4$ profiles per unit CPF (95% CI 15.1–21.7), $r = 0.81$, $R^2 = 0.66$ (Fig. 5). Districts of detached owner-occupied stock carry few profiles. Districts of blocks, shared entrances and shared metering carry many.

6 A field key to the unidentified domestic key

The following couplets assign a ring orphan to a profile group without instruments. Groups aggregate the profiles of the register (§5.2); a specimen that cannot be placed should be recorded as *incertae sedis* and photographed. The letter I is not used in group codes.

1a. Blade absent; shank terminating in a solid boss of equilateral-triangular section . . . . **Group A1** (meter enclosure)

1b. Not as above **2**

2a. Blade present, flat, cuts confined to one edge **3**

2b. Not as above **10**

3a. Bow bearing a moulded or stamped legend **4**

3b. Bow plain, or bearing a maker's mark only **7**

4a. Legend wholly numeric . . . . **Group C** (cam and cabinet; riser and comms enclosures; codes of three or four digits)

4b. Legend containing at least one letter **5**

5a. Legend prefixed FB or CK . . . . **Group C2**

5b. Legend otherwise lettered: a word or abbreviation of a utility, authority or managing agent **6**

6a. Bow pierced by a second hole, subcircular, off-axis **Group D** (refuse store; issued in bulk to blocks)

6b. Bow with single hole . . **Group B** (side and garden gate)

7a. Blade ≥ 40 mm from shoulder datum **8**

7b. Blade < 40 mm **9**

8a. Ward channel single and central (cuts five or six) **Group E** (loft and roof access)

8b. Ward channel double, offset, or absent . . **Group F** (bike store; outbuilding)

9a. Blade of uniform thickness throughout (cuts three or four) **Group G** (stopcock and service covers)

9b. Blade thinned distally, stepped or tapered . . . . **Group H**

10a. Blade present: cruciform, tubular, or flat with cuts on both edges . . . . **Group K** (communal entrance and aerial-box cylinders)

10b. Blade absent **11**

11a. Shank terminating in a plate or socket pierced by a square or hexagonal aperture . . . . **Group J** (window restrictor; radiator)

11b. Not as above **12**

12a. Custodian's dwelling possessing at least one communal fitting . . . . re-run from **1**, admitting wear

12b. Custodian's dwelling possessing no communal fitting within the curtilage . . . . *incertae sedis* (§8)

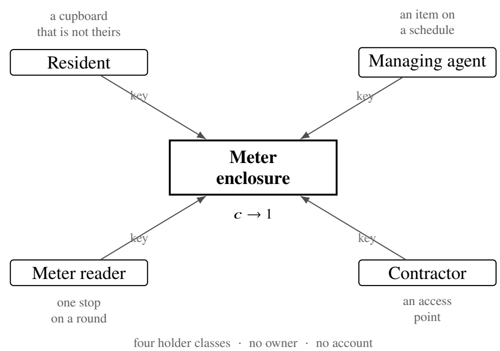

Figure 6: A fitting held by four classes of party and owned by none. Each community uses the same object on its own terms, which is what makes the arrangement work and what leaves the object unattributable. The key inherits both properties.

7 Discussion

The results support a single reading. The unidentified key on a domestic ring is not the residue of a private lock that has been forgotten. It is the residue of a shared one, and it was never individually known.

The mechanism is the one set out in §2.3 (Fig. 6). A communal fitting is used by parties whose purposes do not coincide, and it works precisely because they need not coincide: the resident, the agent, the meter reader and the contractor each treat the same enclosure as a different object. What none of them can do is give an account of it, because an account requires standing, and standing is exactly what a shared fitting distributes away. The key inherits this property. It is legible to everyone as a key and to nobody as *their* key.

This reframes the custodian's failure. Being unable to name the orphan is not a lapse; it is the correct response to an object that was issued without an owner. Custodians are performing accurately.

It also yields a measurement. If orphan profiles are generated by communal fittings, then counting profiles counts communal fittings, and §5.6 shows the relationship is strong and close to linear. The share of a housing stock held in common is currently estimated by survey, at considerable expense and with known response bias. Orphan profile richness offers a direct physical instrument for the same quantity, requiring only a jig and a sampling frame.

The instrument is changing. Richness estimated from the calibration cohort has fallen by 0.9 profiles per decade since 1990, as keyed communal fittings have been replaced by fobs and coded entry. The trend is unambiguous, and it means the present survey is closer to a final reading than to a baseline.

8 Limitations

Non-response was 11.2% and was not uniform: single-occupancy detached households declined at above the sample rate. This is the stratum from which the residue below is drawn, and its under-representation means the residue is likely larger than we report.

The two capture waves are not fully independent. We have reported the wider interval throughout for this reason.

The opening-trial panel is not exhaustive, and 26.6% of orphans matched none of its nine classes. That figure is a property of the panel, not of the specimens.

Stage V dating is censored. Where a stage-V specimen bears on an argument, the argument has been made on the floor of ≥ 31 y rather than on any point value.

The residue is the substantive problem. 6.8% of orphans ($n = 200$) were recovered from detached single-occupancy dwellings with no communal fitting of any class within the curtilage. Their profiles fall in the rare tail of the register, they open nothing in the panel, and their custodians are at chance in naming them. On the account developed in this paper they should not be there. We are unable to say what they are, and we do not think it useful to speculate. They are recorded as *incertae sedis* in provenance and the register is left open against them.

Finally, the communality index of Eq. 2 counts rightful holders and is insensitive to how often each of them actually attends. Two fittings of equal c may differ greatly in traffic, and traffic is what drives wear.

9 Conclusion and recommendations

Ring orphans are near-universal, are not distinct, and open communal fittings. The forgetting account is not merely incomplete; on the discriminating test it fails. The unidentified key was never individually known, because the fitting it opens was never individually held.

Next steps, with responsibility:

1. **Registration.** The forty-one profiles of §5.2 should be lodged as a public register, with the estimate that between one and seventeen further profiles remain unobserved. *Owner:* the national standards body.

2. **Continuous sampling.** Counter sampling at key-cutting concessions should be made routine. It is cheap, and it is the only wave that catches profiles the survey misses. *Owner:* the trade association.

3. **Instrument adoption.** Districts should report profile richness annually, alongside tenure statistics. *Owner:* the statistics agency.

4. **Retention.** Custodians should neither discard nor duplicate a key they cannot identify. Discarding removes a specimen from a closing population. *Owner:* the custodian.

The key is not yours to discard. Photograph it, report it, and leave it on the ring.

Data availability

Jig images, bitting vectors and stage assignments for all 11,412 specimens are held by the Domestic Fittings Survey Group. Household identifiers are withheld. The 41-profile register is available on request, less six profiles held under embargo at the request of the fitting suppliers.

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