

Memory and food intake in sheep: Effects of previous exposure to straw on intake and behaviour later in life

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ABSTRACT

The ban on open-air burning of agricultural by-products by the European Union created disposal problems on many farms. Success was limited in attempts at feeding agricultural by-products like cereal straws to previously grazed livestock. This initial reluctance to accept unfamiliar feeds was also reported when livestock were fed whole-grain cereals in drought, or when grazed on new pastures and shrubs. It is suggested that previous exposure to feed might speed up the rate at which it is accepted, particularly if such experiences take place at pre-weaning. This study aimed at establishing the veracity of this assertion, and whether an early learning experience is carried over into adulthood. Two feeding trials were carried out with lambs not exposed (NE) to straw and those given access to straw at 12 weeks of age for either 10 (E-10) or 28 (E-28) days. At 24 weeks (Experiment 1), 10 lambs from each of the three treatment groups were tested, over 21 days, on their readiness to accept straw as feed. At 36 weeks (Experiment 2), another batch of lambs (from the E-28 and NE groups only) were similarly tested. For each, the lambs were penned individually (in view of lambs from their own treatment group) and also offered a concentrate supplement to meet daily nutrient requirements. In both experiments, intake of straw OM, N and DOM, as well as leaf to stem ratio in reject straw, were assessed for each penned lamb. Animal behaviour pattern was monitored once every 5 min, over an 8-h period, immediately after first confinement. Frequency of eating, idling, ruminating, or drinking were all found to be significantly greater ($P < 0.001$) for previously exposed lambs. Intakes of OM, N, DOM, and leaf fraction in straw were also significantly greater ($P < 0.01$) over the 1st week of assessment. However, the differences ($P > 0.05$) between lambs exposed for 10 or 28 days were not significant in all the parameters measured. Results from these trials support the belief that animals exposed to feeds, pre-weaning, recognize such feeds and accept them later in life more readily than those given such feeds for the first time. The study implies that production systems that expose animals to a wide range of feeds early in life may be advantageous to them later. Research

RÉSUMÉ

ODOI, F. N. A. & OWEN, E.: *Mémoire et la ration alimentaire de mouton: Les effets d'exposition antérieure à la paille sur l'alimentation et le comportement plus tard dans la vie.* L'interdit d'incendie en plein air de sous-produit agricole par l'Union européenne créait des problèmes coûteux de traitement des ordures sur plusieurs champs. Des tentatives pour que les animaux d'élevage qui étaient antérieurement pâturés soient nourries de sous-produits agricoles comme les pailles de céréales ont obtenu peu de succès. Cette réticence initiale d'accepter les aliments étranges a été également signalée lorsque les animaux d'élevage étaient donnés à manger les céréales à grain complet pendant les situations de sécheresse ou bien lorsqu'ils sont pâturés sur les pâturages et les arbrisseaux nouveaux. Exposition antérieure au nouveau aliment, il est suggéré, pourrait activer la rapidité avec la quelle il est accepté, surtout si telles expériences ont lieu avant sevrage. Les expériences signalées dans cet article visait à montrer la véracité de cette affirmation et si les expériences acquises au début sont passées à l'âge adulte. Deux essais d'alimentation étaient entrepris avec des agneaux non exposés (NE) à la paille et ceux exposés à la paille à l'âge de 12 semaines pour 10 (E-10) jours ou 28 (E-28) jours. A l'âge de 24 semaines (Expérience 1), 10 agneaux de chacun de trois groupes de traitement étaient mis à l'essai, pendant 21 jours, pour leur empressement d'accepter la paille comme aliment. Encore, à l'âge de 36 semaines (Expérience 2). Un autre groupe d'agneaux (les groupes de E-28 et NE seulement) étaient mis à l'essai de la même manière. Dans chacun de cas, tous les agneaux étaient individuellement enclos (selon les agneaux de leur propre groupe de traitement) et nourris de concentré complémentaire pour satisfaire les besoins nutritifs quotidiens. Dans les deux expériences, la consommation de matière organique (MO), azote (A) et matière organique digestible (MOD) de la paille, ainsi que la proportion de feuille contre tige de la paille de rejet, étaient évaluées pour chaque agneau enclos. Le type de comportement d'animal était suivi de près une fois tous les 5 min, au cours d'une période de 8 h, immédiatement suivant la première consigne. La fréquence de consommation, de

protocols may need to look more into the feeding history of experimental animals, particularly those assembled from different backgrounds. It may also be possible to exploit this observed behavioural pattern to "prepare animals" early in life to either accept or reject particular feeds they may meet later in life.

fainéantise de rumination ou de boire étaient tous trouvés d'être considérablement plus élevés ($P < 0.001$) pour les agneaux antérieurement exposés. Les consommations de MO, A, MOD et la fraction de feuille de la paille étaient également considérablement plus élevés ($P < 0.01$) au cours de la première semaine d'évaluation. Toutefois, il n'y avait pas de différences considérables ($P > 0.05$) entre les agneaux exposés pour 10 ou 28 jours dans tous les paramètres mesurés. Les résultats de ces essais semblent soutenir la croyance que les animaux exposés aux aliments, avant sevrage, reconnaissent plus facilement tels aliments et les acceptent plus tard dans la vie que ceux qui reçoivent tels aliments pour la toute première fois. Une implication de ces études est que les systèmes de production qui exposent les animaux à une grande variation d'aliments tôt dans la vie pourraient être avantageux pour eux plus tard. D'autre part, les protocoles de recherche devraient examiner de plus l'histoire alimentaire d'animaux expérimentaux, particulièrement ceux qui sont rassemblés d'horizons différents. Il pourrait être également possible de profiter de ce type de comportement observé pour "préparer les animaux" tôt dans la vie soit pour accepter soit pour rejeter des aliments particuliers qu'ils pourraient probablement rencontrer plus tard dans la vie.

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Introduction

The European Union banned open-air burning of agricultural by-products such as cereal straws in the late 1980s. This created disposal problems for many farmers in the United Kingdom. Initial attempts to use them as feed was unsuccessful, particularly when offered to winter-housed livestock after long periods of grazing (Odoi, 1994). The problem seems more widespread, as many species of farm animals are often reluctant to accept foods offered them for the first time. In Australia, for example, initial intake of whole cereal grains and urea-molasses supplements by cattle and sheep were reported to be variable and unpredictable (Lobato, Pearce & Beilharz, 1980; Provenza & Balch, 1987). Young sheep without experience of wheat have been known to avoid or refuse wheat for up to 10-12 days (Mottershead *et al.*, 1985), and consume less of it for up to 5 weeks, compared with other sheep that are used to wheat.

The effect of such a lack of adaptation on intake is also seen in the efficiency with which ruminants graze (Arnold, 1964), and also browse new pastures

and shrubs (Flores, Provenza & Balch, 1989). Green *et al.* (1984) have suggested that a previous period of exposure might speed up the rate at which inexperienced animals adapt to eating food. This is so if such learning experiences have involved young animals with their mothers. Livestock in the tropics that are exposed to straws and stovers at an early age seem to have little difficulty accepting straw as adults compared to their European counterparts (Odoi, 1994). Getting unexposed livestock to readily accept straw as feed will be a most cost-effective means of getting rid of this waste, and of providing a cheap source of feed for farms.

The two experiments reported here aimed to determine:

1. Whether a previous period spent learning to eat straw as lambs would influence intake of straw as sheep.
2. The length of time lambs needed to be exposed to a new food (straw) for a learning experience to be effectively imprinted.
3. If a dietary experience acquired early in

life, as lambs, would persist in adulthood.

Materials and methods

Two feeding trials with lambs each comprised a 24-week preliminary period, followed by two separate 21-day experimental phases (referred to as Experiments 1 and 2).

Preliminary period

Forty-five ewes, each with day-old twin lambs, were selected and grazed together on rye-grass pasture until the lambs were 12 weeks old. Two groups of 15 dams, with their twin lambs, were then group-housed for either 10 (E-10) or 28 (E-28) days. They were offered straw *ad libitum*, together with a concentrate supplement (at 1200 g ewe⁻¹ day⁻¹), to meet nutrient requirements as lactating ewes (ARC, 1980). Lambs had access to whatever was on offer, and ate or nibbled alongside their dams. Water was also available *ad libitum*. Housed ewes and lambs were turned out to graze rye-grass pasture at the end of the scheduled period of 10 or 28 days' housing.

A third group of 15 dams, with their twin lambs, was not exposed at all to straw (NE), but remained outdoors on rye-grass pasture from birth, throughout the preliminary period.

Lambs in all the three treatments (E-10, E-28 and NE) were weaned, and grazed together thereafter on rye-grass pasture until they were 24 weeks old.

Experimental periods

Experiment 1: At the end of 24 weeks, 10 weaned lambs from each of the three treatments (E-10, E-28 and NE) were selected, dewormed and weighed for a trial to assess intake of straw. Mean live weight for lambs in all the treatments was 43.5 kg (SE 0.76).

Experiment 2: At the end of 36 weeks, 20 other weaned lambs (10 from each of groups E-28 and NE, and not previously used in Experiment 1) were selected for another trial to assess intake of straw. Mean initial live weights of lambs were 39.6 and 46.9 kg (SE 2.05) for exposed (E-28) and non-

exposed groups (NE), respectively. Experiment 2 was the same as Experiment 1 in its conduct (i.e., feeding and data collection procedures).

Feeding and data collection procedures

During the two intake trials, each lamb was penned separately on sawdust bedding in full view of another lamb from its own treatment group. This was arranged to reduce stress induced by complete isolation and also to prevent sheep in different treatments from seeing and copying each other (Odoi & Owen, 1993).

Each penned lamb was offered long barley straw (*Hordeum vulgare* L.), at a fixed rate of 30 g DM kg⁻¹ M day⁻¹, together with a concentrate supplement at 15g DM kg⁻¹ M^{0.75} day⁻¹. The supplement was formulated to enable lambs meet minimum requirements for rumen degradable protein, minerals and vitamins (ARC, 1980). Intake of straw OM was assessed over 21-day periods. Lambs were fed once a day. All straw refused by sheep were collected daily for each pen as described by Wahed *et al.* (1990). Straw offered and refused were sampled daily and bulked over 1-week periods to determine contents of OM and N, as well as the ratio of leaf material to stem in the fractions. Water was available to sheep *ad libitum*.

A study observed lamb behaviour once every 5 min, over an 8-h period immediately after confinement (i.e., on Day 1), in Experiment 1. Activities by sheep were recorded as eating, idling, ruminating, or drinking water.

Results

Table 1 shows the nutrient composition of the barley straw and concentrate supplement offered to lambs over the two experimental periods. Eating ($P<0.001$), idling ($P<0.001$), and ruminating ($P<0.01$) by penned lambs were significantly influenced by previous exposure to straw. Lambs from the two exposed groups (E-28 and E10), however, behaved the same for all these activities (Table 2). In both experiments, the intake of OM, N, DOM and leaf material (Tables 3 and 4) were significantly greater ($P<0.10$) during the 1st week

TABLE 1

Composition of Straw and Concentrate Supplement Offered to Sheep for Experiments 1 and 2

	DM (g kg ⁻¹)	Ash (g kg ⁻¹ DM)	Nitrogen (g kg ⁻¹ DM)	IV-DOM (g OM kg ⁻¹ DM)	Leaf material (g kg ⁻¹ DM)
Straw (Experiment 1)	889	41.2	10.5	398.7	452.5
Straw (Experiment 2)	896	40.4	10.6	398.6	471.8
Concentrate	863.7	34.5	52.1	858.3	-

TABLE 2

Frequency of Occurrence of Certain Behavioural Activities in Sheep on Day of Confinement

Activity	E-28	E-10	NE	SED	Sig.
Eating	29 ^a	28 ^a	10 ^b	3.6	***
Idling	45 ^b	45 ^b	71 ^a	3.9	***
Ruminating	17 ^a	18 ^a	10 ^b	2.1	**
Drinking	1	1	1	0.1	NS

Means in a row with a common letter superscript are not significantly different

* Differences significant at 5 % level ($P < 0.05$)

** Differences significant at 1 % level ($P < 0.01$)

*** Differences significant at 0.1 % level ($P < 0.001$)

NS = Differences not significant at 5 % level ($P < 0.05$)

of confinement for sheep exposed to straw (E-28 and E-10) than for unexposed sheep (NE). This trend for exposed lambs to consume more OM than unexposed ones remained throughout the experiment. However, straw intake was not significantly different ($P > 0.05$) between the two exposed groups (E-28 and E-10) in Experiment 1 (Table 3). In both experiments, sheep previously exposed to straw had significantly lower levels of leaf material in straw rejected compared to unexposed sheep, during the 1st and 2nd weeks of confinement (Tables 3 and 4).

Discussion

In experiment 1, sheep previously exposed to straw (E-28 and E-10) ate significantly more ($P < 0.01$) straw OM than their non-exposed counterparts, particularly during Week 1 of confinement. This was despite the fact that lambs previously exposed

to straw had not had access to or been in contact with straw for up to 8 weeks (in Experiment 1) or 20 weeks (in Experiment 2), before the start of these trials to assess intake. Differences in intake between groups previously exposed to straw (E-28 and E-10) were not significant ($P > 0.05$) throughout Experiment 1.

These observations imply that lambs that had been exposed to straw early in life with their mothers had learned to eat straw over the 10 or 28-day periods. This learned behaviour also persisted for a considerable length of time (up to 20 weeks at least, as in Experiment 2). These observations agree with what had been reported for lambs that had learned to eat whole cereal grain before weaning (Green *et al.*, 1984). However, the results from this work were contrary to those recorded in an earlier trial (Odoi & Owen, 1993), in which older sheep (12-month-old) previously

TABLE 3

Mean Intake of Organic Matter (OM), Leaf Material (LM), Nitrogen (N) and in vitro Digestible Organic Matter (IVDOM) in Straw Consumed by Sheep on Different Treatments (Experiment 1)

Treatment	E-28	E-10	NE	SED	Sig.
<i>Week 1</i>					
Organic matter (g OM/kg M/day)	8.8 ^a	8.6 ^a	6.9 ^b	0.56	**
Leaf material (g DM/kg M/day)	7.6 ^a	7.6 ^a	6.7 ^b	0.14	***
Nitrogen (g DM/kg M/day)	0.13 ^a	0.13 ^a	0.11 ^b	0.005	**
<i>In-vitro</i> digestible organic matter (g OM/kg M/day)	5.3 ^a	5.3 ^a	4.4 ^b	0.20	***
<i>Week 2</i>					
Organic matter (g OM/kg M/day)	10.8	10.7	9.7	0.67	NS
Leaf material (g DM/kg M/day)	9.9 ^a	9.8 ^a	9.6 ^b	0.16	*
Nitrogen (g DM/kg M/day)	0.18 ^a	0.18 ^a	0.16 ^b	0.005	**
<i>In vitro</i> digestible organic matter (g OM/kg M/day)	7.0 ^a	6.9 ^a	6.7 ^b	0.14	NS
<i>Week 3</i>					
Organic matter (g OM/kg M/day)	11.2	10.8	9.9	0.73	NS
Leaf material (g DM/kg M/day)	10.5	10.4	10.2	0.17	NS
Nitrogen (g DM/kg M/day)	0.21	0.21	0.21	0.003	NS
<i>In vitro</i> digestible organic matter (g OM/kg M/day)	7.5	7.4	7.2	0.18	NS

Means in a row with a common letter superscript are not significantly different

* Differences significant at 5 % level ($P < 0.05$)

** Differences significant at 1 % level ($P < 0.01$)

*** Differences significant at 0.1 % level ($P < 0.001$)

NS = Differences not significant at 5 % level ($P < 0.05$)

exposed to straw did not seemingly eat any more straw later than their unexposed counterparts.

Observations from this work support the conclusion that neither the length of the exposure period nor the interval between exposure and re-testing significantly influence intake for sheep that had been previously exposed to a feed. Important differences show up, however, when the previous exposure to a new feed takes place with or without dams, that is, if done before weaning (Lynch *et al.*, 1983). Lobato *et al.* (1980) have argued that maternal influence at the time of exposure was probably the most important factor ensuring ready acceptance of feeds later in life. This is probable because mothers enhance the learning process of their offspring, compared with unrelated individuals (Morgan & Arnold, 1974). The learning process may be further boosted through

the bonding action between mother and offspring. This may exert subtle but marked influences through transmission of odours and tastes, *via* milk (Galef, 1976; Madsen, 1977). There seems, therefore, to be a "sensitive or critical period", early in the life of the animal, during which it is readily influenced in its learning experiences. In the feeding relationship between mother and offspring, it is thought that this critical period coincides with or around the time of weaning (Provenza & Balph, 1987).

In Experiments 1 and 2, lambs previously exposed to straw seemed better at selecting leaf material in the straw on offer than non-exposed lambs, particularly within the period soon after confinement in Week 1 (Tables 3 and 4). Such lambs did not only consume more feed, but also ate much better quality feed (i.e., one containing

TABLE 4

Mean Intake of Organic Matter (OM), Leaf Material (LM), Nitrogen (N) and in vitro Digestible Organic Matter (IVDOM) in Straw Consumed by Sheep on Different Treatments (Experiment 2)

<i>Treatment</i>	<i>E-28</i>	<i>NE</i>	<i>SED</i>	<i>Sig.</i>
<i>Week 1</i>				
Organic matter (g OM/kg M/day)	8.7	6.2	0.83	*
Leaf material (g DM/kg M/day)	6.5	4.9	0.55	*
Nitrogen (g DM/kg M/day)	0.09	0.07	0.008	**
<i>In vitro</i> digestible organic matter (g OM/kg M/day)	5.3	4.0	0.42	*
<i>Week 2</i>				
Organic matter (g OM/kg M/day)	11.9	10.4	0.73	NS
Leaf material (g DM/kg M/day)	7.2	6.2	0.47	NS
Nitrogen (g DM/kg M/day)	0.16	0.14	0.010	*
<i>In vitro</i> digestible organic matter (g OM/kg M/day)	6.4	5.5	0.40	*
<i>Week 3</i>				
Organic matter (g OM/kg M/day)	12.5	10.9	0.81	NS
Leaf material (g DM/kg M/day)	7.0	6.1	0.47	NS
Nitrogen (g DM/kg M/day)	0.13	0.12	0.009	NS
<i>In vitro</i> digestible organic matter (g OM/kg M/day)	6.9	5.9	0.48	NS

Means in a row with a common letter superscript are not significantly different

* Differences significant at 5 % level ($P < 0.05$)

** Differences significant at 1 % level ($P < 0.01$)

*** Differences significant at 0.1 % level ($P < 0.001$)

NS = Differences not significant at 5 % level ($P < 0.05$)

more digestible organic matter and nitrogen) than the others. This was reflected in the previously exposed lambs visiting feed troughs more frequently, ruminating more often and idling less, compared with their non-exposed counterparts (Table 2).

Implications of the study for animal production and research

In the light of these findings, it may be argued that the much maligned "free-range" system of feeding livestock practised in many rural farming systems in the developing tropics, including Ghana, may be beneficial. It could be helping animals to adapt to many new feeds early in life, when they are most likely to do so effectively. This might help explain why most tropical livestock, which are exposed to straws, stovers

and a wide range of other feeds early in life and throughout their lives (unlike their temperate counterparts), seemingly cope better with sudden changes in feed. This ability must not be lost in our part of the world where the unpredictable climate and drought make the availability of forage rather erratic. In an attempt to promote large-scale ranching on cultivated pastures in Ghana and elsewhere in the developing tropics, sight should not be lost of the adaptive benefits of the existing traditional livestock farming system which "trains" livestock to eat many different feeds, early in life.

Research protocols might need to seriously consider the feeding history of experimental animals being used, particularly if they have been purchased or assembled from very different backgrounds. Their feeding history might have a

long-term influence on their acceptance of experimental feeds offered than has been imagined. The traditional adjustment period of between 14 and 21 days adopted for feeding trials may not be enough to completely remove all background differences in eating behaviours to allow for unbiased comparisons in feed intake between experimental animals. This will be so for any exposure in early life; as such feeding experiences seem to be retained over a long period. Differences in intake and performance between experimental animals may then not be due entirely to differences in feed quality between treatments. The feeding history of animals may also be exerting significant but subtle influences, over long periods, on intake and the ability to select, particularly on non-homogenous feeds.

Until recently, little attention had been paid to the possibilities afforded by the effects of such early learning experiences in manipulating feed intake in livestock. For example, it may be useful to take advantage of this observed trend in a production setting to prepare young animals to cope better with, or even avoid certain feeds that they may meet or be exposed to as adults. These could include nutritious but unpalatable feeds, like *Gliricidia sepium*, or even toxic plants that constitute a problem to livestock on rangeland. The benefits of such "training" would help livestock to readily accept nutritious feeds they avoid or only accept reluctantly. This will increase the feed resource base on the farm and reduce plant poisoning of animals at pasture.

Conclusion

Results from these trials, and the earlier study cited (Odoi & Owen, 1993), establish and also lend credence to the held assertion by many farmers that:

1. Livestock react poorly, initially, to most feeds new to them.
2. A previous exposure to feed improves its acceptance later in life, particularly if animals had been with their mothers when exposed. This is so even when animals
3. Dietary behaviour acquired while with mothers seems to be retained long-term, with animals able to recognize and accept such feeds when offered them later.
4. Previous exposure to new feeds as adults (i.e., post-weaning), however, seems not to be quite as effective in getting sheep to retain a memory for that feed later in life (Odoi & Owen, 1993).

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