



Figure 2. Map showing distribution of *P. kashyapii* Asthana et Sriv. in India.

possess minutely papillate sporoderm. *P. udarii* can be easily differentiated from *P. kashyapii* by possessing minutely papillate projections over the elateroderm, whereas *P. himalayensis* is quite separable by hump-like marks on the sporoderm.

Occurrence of *P. kashyapii* (see Figure 2) in the three major bryogeographical regions of India, between an altitudinal range of 1320 ft in Central India and 10,890 ft in western Himalayas, suggests the widespread nature of this taxon and its adaptability to grow in varied ecological conditions.

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Plant proteins in fish feed

Profitable fish culture requires unfailing supply of formulated fish feed in which proteins serve as both growth nutrient and energy currency. Thus, formulation of low-cost feeds using the cheapest sources of proteins is essential to hasten fish production and to reduce feed cost¹. With the objective, studies on plant protein sources (PPSs) are continuing at present. But a recent analysis of data from 87 papers revealed a low positive correlation ($r = 0.177$; $n = 377$) between dietary crude protein (DCP in %) of PPS-based feeds and specific growth rate (SGR), and high negative correlation ($r = -0.990$; $n = 332$) between DCP and protein efficiency ratio (PER) of farmed

fishes². Evidently, use of PPS-based feeds in profitable fish culture is still a matter of extensive research.

SGR and PER are conversion (growth)-based estimates. In bioenergetics, absorption (A) precedes conversion. A is quantified as absorption efficiency (Ae). It is an index of the proportion of ingested food (C) that is transferred from the gut lumen into the body of a fish ($Ae = A/C \times 100$)³. Ae is primarily influenced by both quantity and origin of proteins in feeds. Fishes digest high proteinaceous diets more efficiently⁴. Plant diets with low natural proteins reduce the Ae of fishes^{5,6}. Pandian³ also summarized mean Ae values as 89 and 44%

for fishes on animal and plant diets respectively. This report is first aimed to estimate the DCP–Ae relationship in an earlier dataset² on PPS-based feeds. In this context, food nitrogen (N in %) is positively ($r = 0.959$; 50 species) and significantly correlated with Ae of fishes. Ae is also predictable from N using the regression model: $\log Ae = 1.3706 + 0.5807 \log N$. The second aim is to get a new outlook to the Ne–Ae relationship using an earlier dataset² on PPS-based feeds.

Among the 100 values regressed in the previous analysis⁷, 52 pertain to 32 species fed on high N-containing (5.7–13.7; mean: 9.855%) animal diets and 22 pertain to

13 species fed on low N-containing (0.3–5; mean: 3.090%) plant diets. Clearly, there is a preponderance of data from high N-containing animal diets (figure 1 in ref. 7). It leads to the doubt that prediction accuracy of N–Ae relation may be reduced at low N levels in diets. To gain insight, Pandian and Marian⁷ also made an ancillary analysis for low N-containing plant diets. The estimated *r* (0.905; 13 species) and linear regression are significant at *P* < 0.01 only. The percentage of variation accounted by N in Ae is also low (82%). This low sample size (*n* = 22) is only due to lack of data on Ae of fishes fed on low N-containing plant diets at that time of analysis.

The dataset of recent analysis² from current literature provides an opportunity for estimating N–Ae relationship on feeds formulated mainly from PPS. Among the 125 values selected for the present analysis from an earlier dataset², 46 pertain to low N range of 1.07–4.96% (mean: 3.717), which fulfils the missing data on low N level in the earlier work⁷, as well as falls below the lower limit (5.7%) of the high N range that was regressed earlier⁷. Thus analysis of N–Ae relationship on PPS-based feeds with low N levels is the third aim.

Unfortunately, in most of the recent papers, there are no data on Ae of fishes and feed N^{8,9}. So from an earlier dataset², 125 DCP (%) values were selected. They are minimum and maximum values from 87 papers for 53 species. Repetition of data for the same species is either omitted or selectively reduced. Feed N is recalculated from DCP by dividing it with 6.25, as in an earlier report⁷. Ae is estimated by substituting N values in the proposed prediction model⁷. These datasets can be ob-

tained from the author. They were analysed for correlation and linear regression.

Table 1 shows the results. In the present dataset, DCP ranges from 6.7 to 61.2%, with a mean of 36.64. Ae ranges from 24.4 to 88.3%, with a mean of 64.2. DCP of PPS-based feeds is positively (*r* = 0.939) correlated with Ae of fishes. The percentage of variation explained by DCP in Ae is high (88.3%). The results suggest that (i) in general, protenacious feeds are efficiently assimilated by fishes and (ii) in particular, PPS-derived proteins increase the Ae of chosen fishes.

N ranges from 1.07 to 9.79%, with a mean of 5.84 in the present dataset. N of PPS-based feeds is positively (*r* = 0.984) correlated with Ae of fishes with high percentage of *r*² (96.9%). The magnitudes of *r* and *r*² are much greater than their respective values for the DCP–Ae relationship. The inferences are: (i) N quantitatively influenced Ae more than DCP; (ii) N of PPS-based feeds enhances the Ae of fishes, and (iii) feed N can be used as predictor of Ae in fishes. It is also remarkable that the *r* and *r*² of the present dataset for PPS-based feeds are much greater than the values reported earlier for high N-containing animal diets.

Results of N–Ae relationship on low N level (1.07–4.09%) of PPS-based feeds are also remarkable. N is positively correlated (*r* = 0.988; *n* = 46) with Ae fishes (25 species). The *r*² (99.2%) is very high. The earlier study⁷ used log-transformed data. The present study also attempted the same. Result shows high positive correlation (*r* = 0.982) between low N and Ae. Thus, the prediction accuracy of the N–Ae relationship at low N levels in the diets is also

as high as that of high N-containing diet. It confirms the earlier proposal of using N as the predictor of Ae in fishes.

Earlier studies have shown low Ae on plant diets^{5,6}. In contrast, enhanced Ae on PPS-based feeds (24.4–88.4; mean: 63.8%) in the present study for the whole and low N datasets may be due to: (i) contributions of non-protein N, a major source of N in PPS¹⁰; (ii) removal/inactivation of anti-nutritive factors (ANFs) and toxins by special methods; (iii) control of other Ae-influencing factors in experiments; (iv) increase in N and DCP due to inclusion of one more PPS in most of the works, and (v) inclusion of animal protein (fish meal protein), an Ae-enhancing factor as secondary source.

It is clear that both N (even at low level) and DCP of PPS-based feeds have enhanced the Ae of fishes. But recent work² revealed that this energy is not converted into growth after absorption (see also references therein). Similarly, natural plant diets reduce the growth in fishes^{11,12}. Even high Ae values on plant diets have coupled with low conversion efficiency in fishes^{13–15}. Exact reasons for this low conversion are not clear. Some convincing reasons in relation to PPS-based feeds are: (i) use of amino acids as metabolic fuel after absorption³; (ii) unfit for body protein synthesis as nonessential amino acids¹⁶; (iii) interference by secondary metabolites and ANFs^{10,16}; (iv) imbalance in protein–energy ratio, especially at higher levels of DCP; (v) reduction in feeding rate, a growth-deciding factor^{17,18}, and (vi) significant energy loss as non-faecal N^{12,19}. Intensive browsing of the literature may also identify more reasons.

One can argue back and forth, quoting evidences which either support or contradict these conclusions. Estimated *r* values appear to be overestimates due to: (i) overestimation of DCP in original papers as 6.25 × N and N as DCP/6.25; (ii) very low N content (0.03–1.7%) with mean 2% in PPS¹⁰; (iii) high qualitative variations in such low quantity N⁸; (iv) error (8%) introduced by prediction model in Ae values⁷; (v) direct evidences as low Ae on plant diets in fishes^{5,6}; (vi) low *r* value (0.905) for N–Ae relationship in herbivorous fishes⁷; (vii) interference of N-based toxins and non-N-based digestibility reducing chemicals of PPS^{10,16} in digestion and absorption of DCP, and (viii) reduction in activity of digestive enzymes by PPS-based feeds, especially protease^{20,21}.

In conclusion, future studies need to focus on: (i) evaluation of PPS-based feeds

Table 1. Correlation and regression matrix for selected datasets

Statistics	Estimate			
	DCP vs Ae (<i>n</i> = 125)	N vs Ae**		
		(<i>n</i> = 125)	1 (<i>n</i> = 46)	2 (<i>n</i> = 46)
Range of DCP/N (%)	6.7–61.2	1.07–9.79	1.07–4.90	1.07–4.90
Correlation coefficient (<i>r</i>)	0.9398*	0.9844*	0.9880*	0.9820*
Coefficient of determination (<i>r</i> ²)	0.8833	0.9690	0.9761	0.9643
Standard error (SE) of <i>r</i>	0.0379*	0.0159*	0.0233*	0.0285*
Probable error (PE) of <i>r</i>	0.0207	0.0107	0.0157	0.0192
<i>t</i> for SE of <i>r</i>	3.051	61.856	42.434	34.492
Regression coefficient (<i>b</i>)	1.1532*	7.0508*	0.1190*	1.730*
SE of <i>b</i>	0.1971*	0.1146*	0.0027*	0.0234*
<i>t</i> for SE of <i>b</i>	5.852	61.516	42.960	74.052
Intercept (<i>a</i>)	21.570	23.076	-2.172	-5.460

*Significant at *P* < 0.001.

**1, *n* = 46 for untransformed data; 2, For data transformed with natural log.

in terms of Ae of fishes; (ii) intensive investigations on PPS resulting in maximum Ae for a given species; (iii) inclusion of more sources of PPS to enhance total N and DCP; (iv) intensive research on PPS, which results in better Ae in more fishes; (v) partial substitution of non-protein N and animal proteins to enhance Ae; (vi) development of inexpensive methods for removal/inactivation of ANFs; (vii) special methods for removal of enzyme inhibitors, and (viii) supplementation of essential amino acids.

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Palaeolithic tools from the surface of optically stimulated luminescence dated alluvial fan deposits of Pinjaur Dun in NW sub-Himalayas

For a long time, the Sohan-type palaeolithic tools found from the river terraces of NW sub-Himalayas had been relatively dated on the basis of alpine glaciations chronology, suggested by De-Tera and Patterson¹. Later workers^{2–6} in the Indian part of the subcontinent continued research based on the same approach, and the late-Sohan stone tools found by some workers^{4,5} from Pinjaur Dun and its adjoining regions were also assigned dates pertaining to the then-accepted third glacial or third inter-glacial stages of terrace formations. Naturally, such tools were thus thought by them to have been manufactured much before 70 ka BP (the tentative date of the onset of the last phase of glaciations, according to the alpine glaciations chronology). However, now we know that the relative chronology of the sub-Himalayan river terraces, as suggested

by De-Tera and Paterson, is not being considered as true since the number of Pleistocene glaciations greatly exceeded⁷ the number of river terraces that were earlier identified and accepted by almost all researchers^{1–6}. We therefore need to search for new evidence that may be available for working out a true chronology of the Sohan type tools and their sites, particularly in the absence of absolutely datable material. If in some cases, the absolute age of the surface on which some stone tools are found is known, it will certainly provide us with a lower limit to the date of fabrication/use of these tools. Recently, Suresh *et al.*⁸ have dated the deposition of alluvial fan surface of Pinjaur Dun using optically stimulated luminescence (OSL) method, in which the age of sedimentation of the uppermost terrace of Luhund Khad (a rivulet incising

the alluvial fans and joining the river Satluj near Kiratpur–Punjab) is determined to be around 20 ka BP. Like thermoluminescence (TL) dating, OSL dating is also related to the absorption of nuclear energy by minerals. Here, by exposure of certain minerals to sunlight⁹, there is optical bleaching during the pre-depositional transportation of the sediment. Following burial, natural minerals start acquiring fresh luminescence from the radioactive minerals present in the sediments. The time elapsed since deposition can be determined by calculating the ratio of the acquired luminescence to the annual rate of its acquisition since burial. Hence the time elapsed since the last exposure to sunlight is determined giving an absolute age to the sediment deposition. An exploration done by the present authors on these dated terrace surfaces was successful and a number of