The following supplements accompany the article

Modelling biogeochemical fluxes across a Mediterranean fish cage farm

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Supplement 1. Further details on individual-based growth models

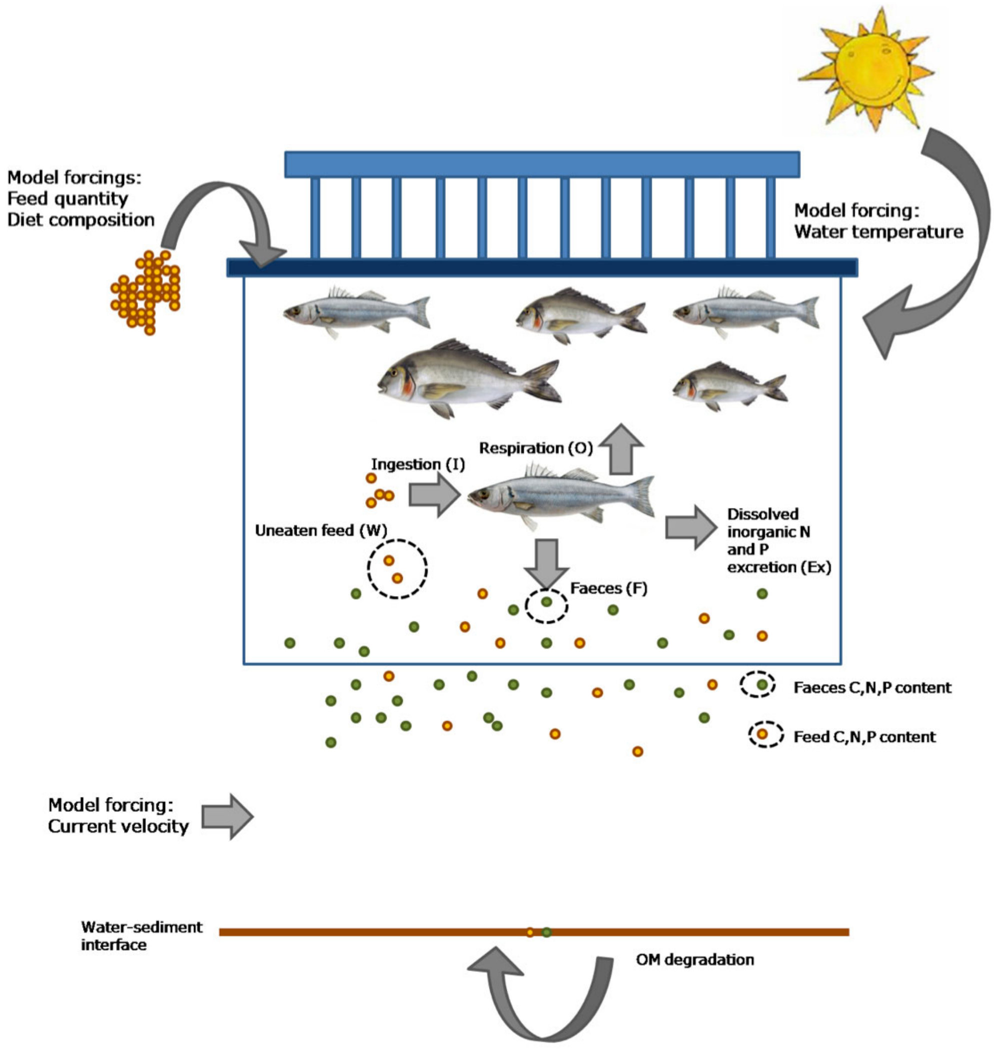

Fig. S1. Schematic representation of processes covered by the seabream and seabass growth models

Table S1. Functional expressions used in the individual growth models

State variable:

w: fresh weight (g)

Growth equation:

$$\frac{\mathrm{d}w}{\mathrm{d}t} = \left(\frac{A - C}{\varepsilon_T}\right) \quad \text{(S1)}$$

A: net anabolism (J d^{-1})

C: fasting catabolism (J d^{-1})

ε_T: energy content of somatic tissue (kJ g^{-1})

Forcings:

T_w: water temperature (°C)

R: amount of feed provided by the farmer per individual (g d^{-1})

C_P: % of proteins in the ingested feed

C_C: % of carbohydrates in the ingested feed

C_L: % of lipids in the ingested feed

1. Functional expressions for net anabolism

$$I = I_{max} \cdot H(T_w) \cdot w^m \quad \text{(S2)}$$

I: daily ingestion rate (g d^{-1})

I_{max}: maximum ingestion rate (g d^{-1} g^{-m})

m: weight exponent for the anabolism

$H(T_w)$: see Eq. S7

$$\begin{cases} I = R & , when\ I \geq R \\ I = 0 & , when\ T < T_a \end{cases} \quad \text{(S3)}$$

T_a: lowest feeding temperature

$$A = (1 - \alpha) \cdot I \cdot (C_P \cdot \varepsilon_P \cdot \beta_p + C_C \cdot \varepsilon_C \cdot \beta_C + C_L \cdot \varepsilon_L \cdot \beta_L) \quad \text{(S4)}$$

$$F = I \cdot \left[C_P \cdot (1 - \beta_p) + C_C \cdot (1 - \beta_C) + C_L \cdot (1 - \beta_L)\right] \quad \text{(S5)}$$

F: faeces production (g d^{-1})

α: feeding catabolism coefficient

β_P, β_C, β_L: assimilation coefficients for protein, carbohydrate and lipid

ε_P, ε_C, ε_L: energy content of protein, carbohydrate and lipid (kJ g^{-1})

2. Functional expressions for fasting catabolism

$$C = \varepsilon_{O2} \cdot k_0 \cdot K(T_w) \cdot w^n \tag{S6}$$

ε_{O2}: energy consumed by the respiration of 1 g of oxygen (kJ g^{-1})

k_0: fasting catabolism at 0°C (d^{-1} g^{-n})

n: weight exponent for the catabolism

$$H(T_w) = \left(\frac{T_m - T_w}{T_m - T_o}\right)^{b(T_m - T_o)} \cdot e^{b(T_m - T_o)} \tag{S7}$$

b: shape coefficient for the $H(T_w)$ function

T_o: optimal temperature (°C)

T_m: maximum lethal temperature (°C)

$$K(T_w) = e^{pk \cdot T_w} \tag{S8}$$

pk: temperature coefficient for the fasting catabolism (°C^{-1})

O: daily respiration rate (d^{-1})

$Ex_{N,P}$: daily dissolved N,P excretion rates (d^{-1})

$$O = k_0 \cdot K(T_w) \cdot w^n \tag{S9}$$

$$Ex_N = O \cdot k_{N:O} \tag{S10}$$

$$Ex_P = O \cdot k_{P:O} \tag{S11}$$

3. Wasted feed

W: uneaten feed [g d^{-1}]

$$\begin{cases} W = R - I & \text{, when } R \geq I \\ W = 0 & \text{, when } R < I \end{cases} \tag{S12}$$

Parameterization of the European seabass *Dicentrarchus labrax* model

The fasting catabolism parameters k_0 and *pk* were estimated on the basis of the oxygen consumption measurements by Claireaux & Lagardère (1999). A value of 1 for the weight exponent for the catabolism, *n*, was used (Ursin 1967). I_{max}, defining the ingestion rate at the optimal temperature, and the coefficient *m*, which quantifies the dependence of the ingestion rate on the individual weight, were estimated with ingestion data reported by Lupatsch et al. (2001). The feeding catabolism coefficient, α, quantifying the energy costs for digestion, assimilation, transportation, biochemical treatment and incorporation of food, was estimated by Stirling (1977). The protein digestibility coefficient, β_P, fixed at 88%, was set on the basis of the results obtained by Dosdat (2001) and Moreira et al. (2008). The lipid digestibility coefficient, β_L, was set at 97% according to Dosdat (2001) and Boujard et al. (2004). For carbohydrates, β_C at a value of 84% was used according to Boujard et al. (2004) and Krogdahl et al. (2005). Energy contents for proteins, ε_P, lipids, ε_L, and carbohydrates, ε_C, were measured by Brett & Groves (1979). Energy loss associated with the respiration of 1 g of oxygen, ε_{O2}, was quantified by Brafield & Solomon (1972) and then corrected by Elliott & Davison (1975) for ammoniotelic animals. The energy content of somatic tissue, ε_T, was estimated from caloric content measurements reported by Lupatsch et al. (2003). An optimal temperature (T_o) of 22°C and a maximum lethal temperature (T_m) of 32°C were selected according to Barnabé (1990). A lower feeding threshold of 7°C was considered, below which fish have no appetite (Tesseyre 1979, Pastoureaud 1991).

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Table S2. Parameters used in the *Sparus aurata* growth model (parameter sources are reported in Brigolin et al. 2010)

Parameter	Description	Value	Unit
I_{max}	Maximum ingestion rate	0.09	(g feed g fish^{-m} d^{-1})
α	Feeding catabolism coefficient	0.3	–
β_P	Assimilation coefficient for protein	0.85	–
β_C	Assimilation coefficient for carbohydrate	0.50	–
β_L	Assimilation coefficient for lipid	0.95	–
ε_P	Energy content of protein	23.6	(kJ g^{-1})
ε_C	Energy content of carbohydrate	17.2	(kJ g^{-1})
ε_L	Energy content of lipid	36.2	(kJ g^{-1})
ε_{O2}	Energy consumed by the respiration of 1g of oxygen	13.6	(kJ g $O_2$$^{-1}$)
ε_T	Energy content of somatic tissue	9.90	(kJ g^{-1})
pk	Temperature coefficient for the fasting catabolism	0.06	(°C^{-1})
k_0	Fasting catabolism at 0°C	0.00072	(g O_2 g fish^{-1} d^{-1})
M	Weight exponent for the anabolism	0.6	–
N	Weight exponent for the catabolism	1.0	–
b	Shape coefficient for the $H(T_w)$ function	0.16	–
T_a	Lowest feeding temperature for *Sparus aurata*	12	(°C)
T_o	Optimal temperature for *S. aurata*	25	(°C)
T_m	Maximum lethal temperature for *S. aurata*	32.9	(°C)

Supplement 2. Farming cycle at the Bisceglie farm and *Dicentrachus labrax* model validation

As concerns *Sparus aurata*, 2 cycles of approximately 15 mo were carried out in Cage 2; a single cycle lasting approximately 8 mo occurred in Cages 3 and 4; and a single cycle of 22 mo in Cage 6. For *Dicentrarchus labrax*, a total of 9 rearing cycles in 5 of the 6 cages were simulated according to the husbandry practices information: 2 rearing cycles of 17 and 9 mo each in Cage 1; 2 cycles of 15 and 2 mo each in Cage 2; a cycle of 21 mo in Cage 4; 2 cycles of 12 and 18 mo each in Cage 5; and 2 cycles of 22 and 6 mo each in Cage 6.

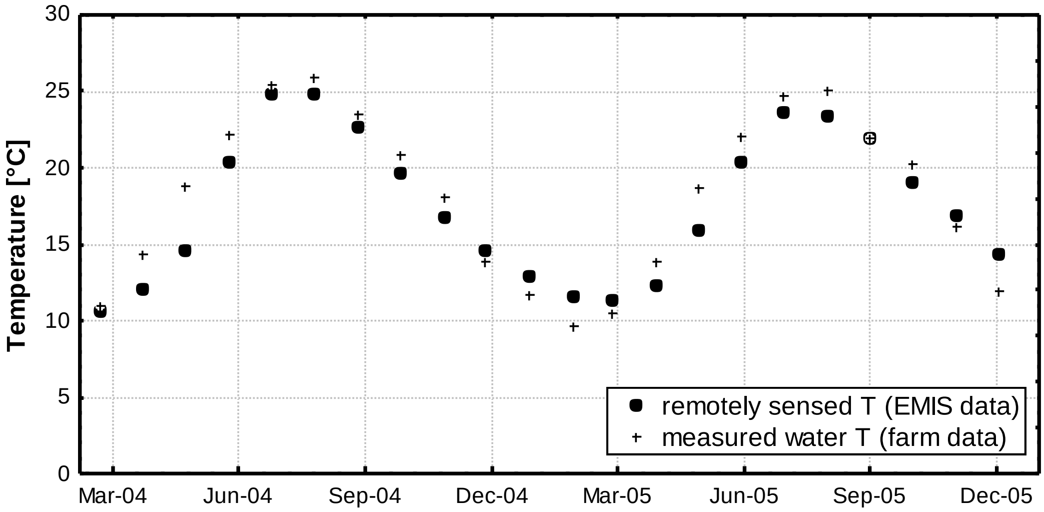

Fig. S2. Comparison between *in situ* measured water temperature (T) and remotely sensed water temperature (downloaded from the EMIS-JRC website at http://emis.jrc.ec.europa.eu/)

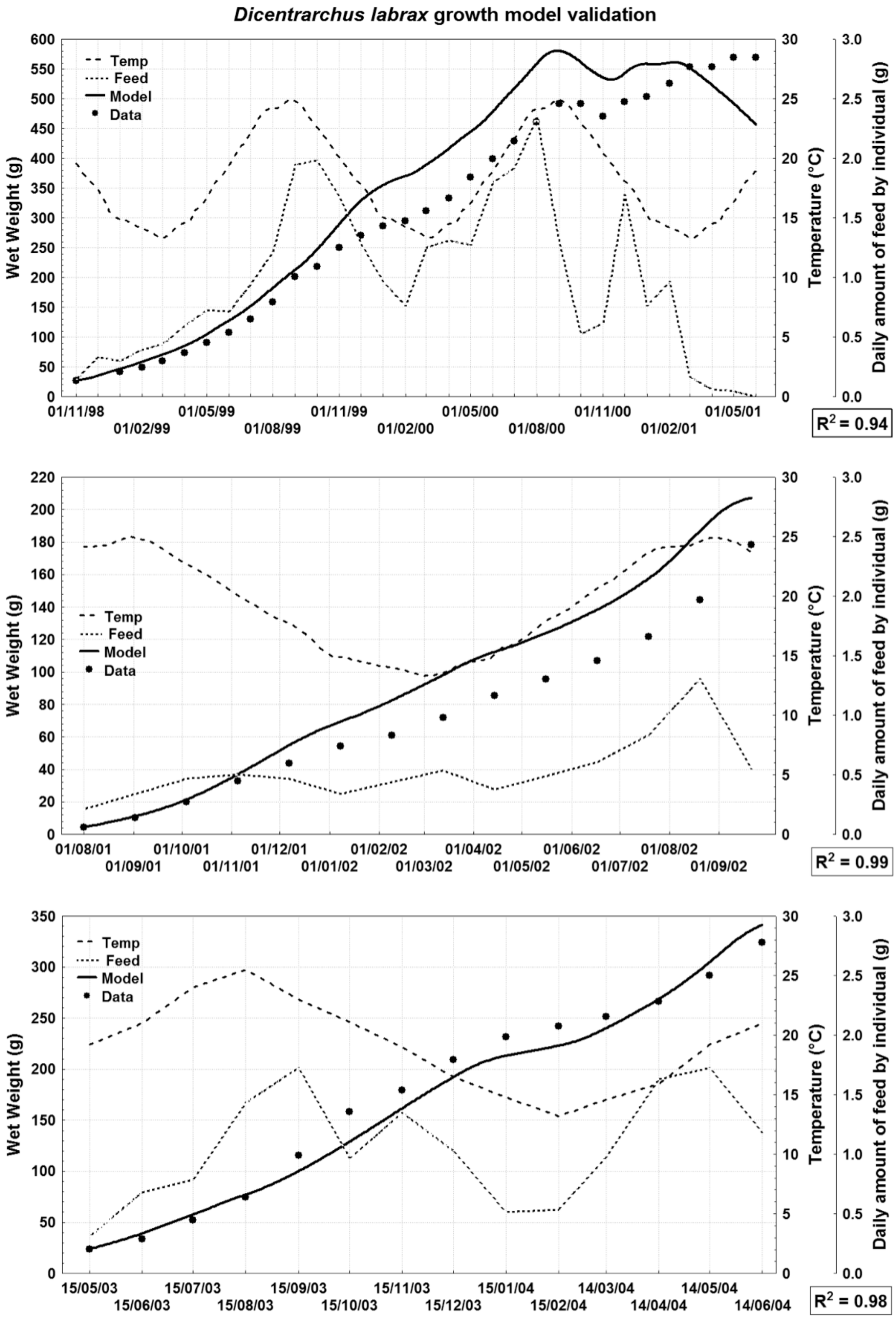

Fig. S3. Validation of the *Dicentrarchus labrax* growth model for 3 available periods of data in Porto Ercole, Tyrrhenian Sea (see Fig. 1 in the main text). Dashed lines: water temperature (°C); dotted lines: the daily amount of feed available by individual fish per day (g); continuous lines: the wet weight (g) predicted by the model; dots: the wet weight from field observations (g)

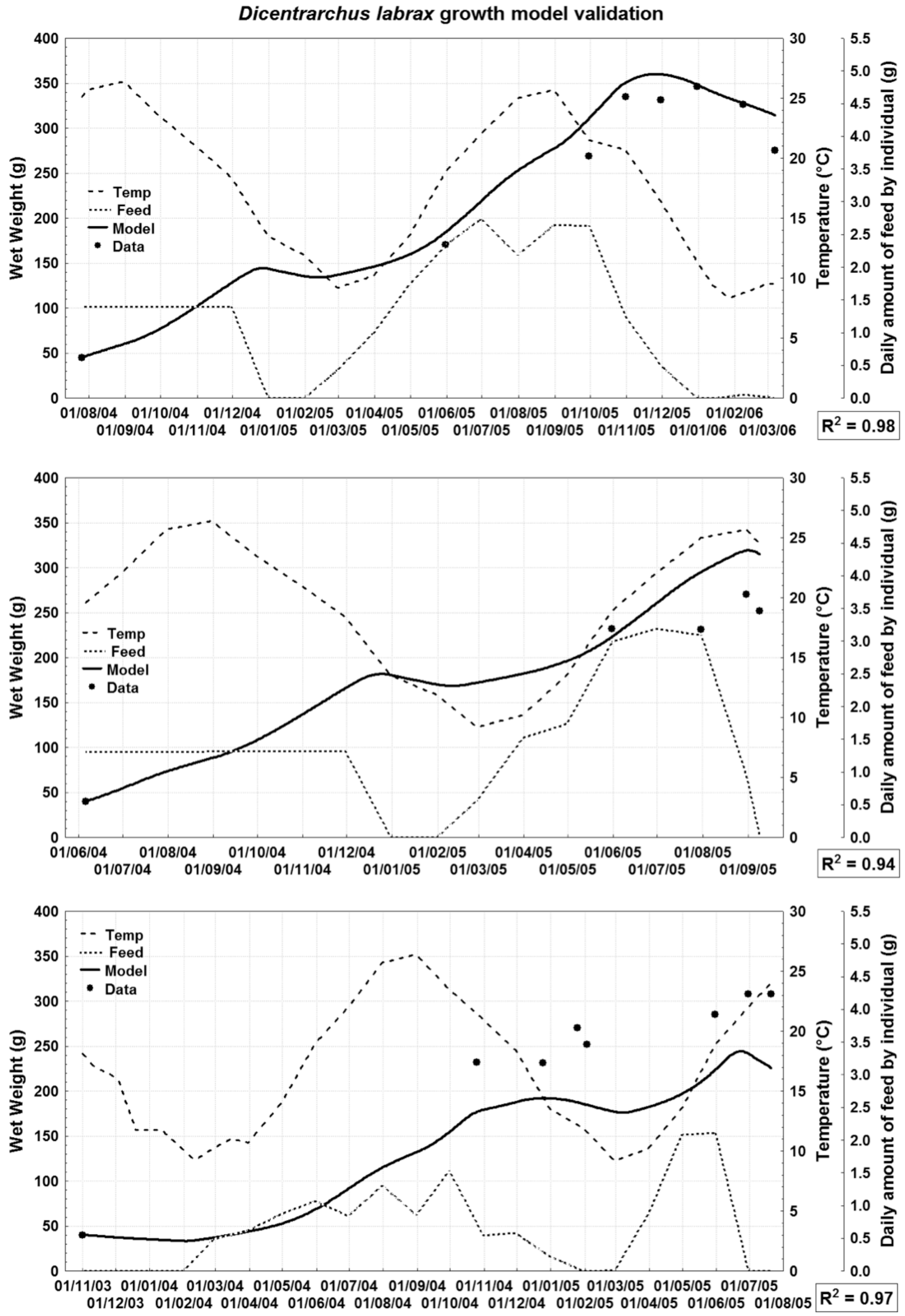

Fig. S4 (continued on next page). Validation of the *Dicentrarchus labrax* growth model for 6 available periods of data in Bisceglie, southern Adriatic Sea (see Fig. 1 in the main text). Dashed lines: water temperature (°C); dotted lines: the daily amount of feed available by individual fish per day (g); continuous lines: the wet weight (g) predicted by the model; dots: the wet weight from field observations (g)

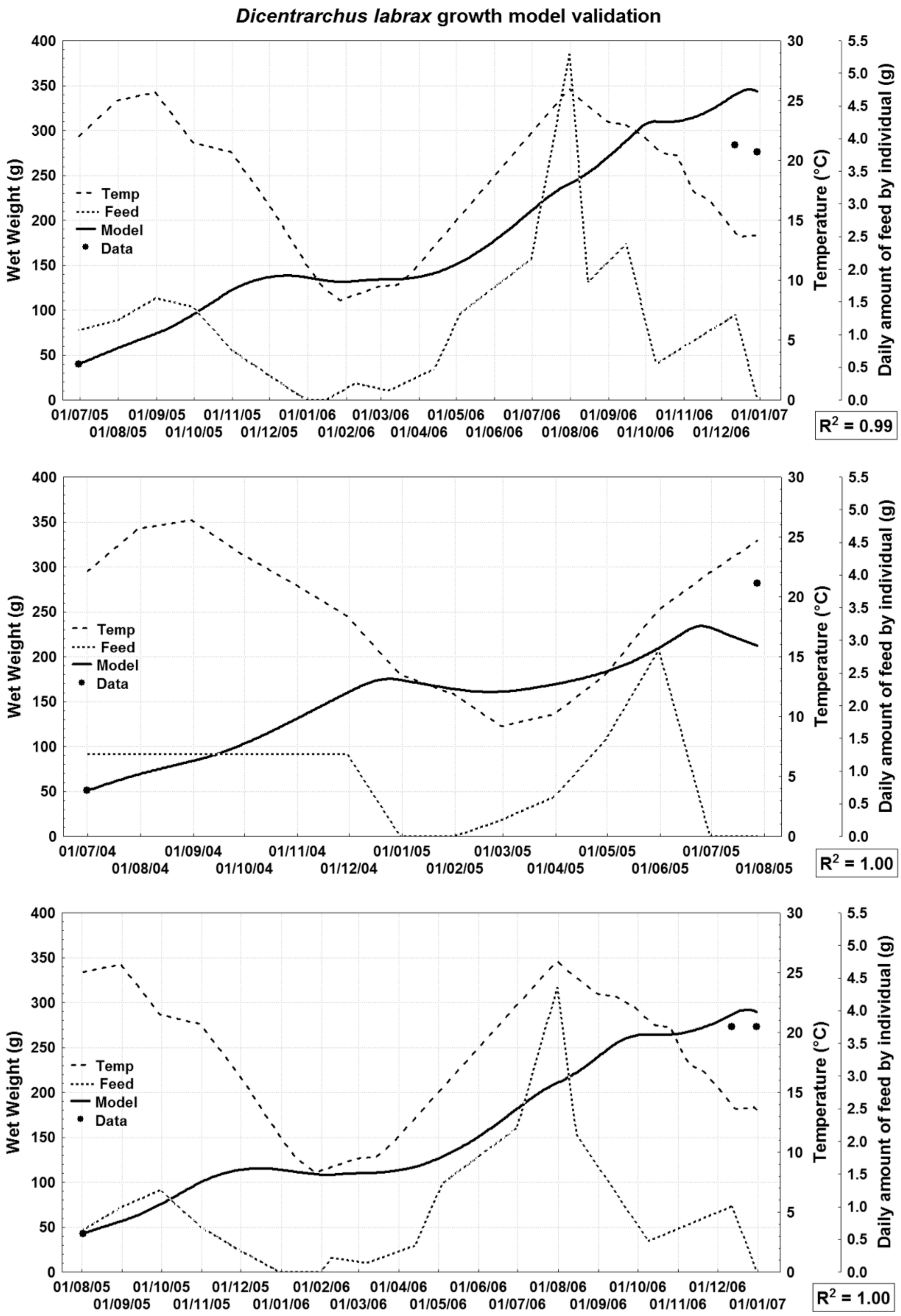

Fig. S4 (continued)